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A Study of Building Procedure in the Dominican Republic

-How to develop a sustainable building process.
-Are there applicable models and techniques from Sweden?

Caroline Knutsson
Kristina Myrberg

THESIS FOR BSC 2009
CIVIL ENGINEERING

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This thesis is written at the Department of Civil Engineering at the School of Engineering, Jönköping University. The thesis is the final part of the three years engineering education. The authors themselves are individually responsible for presented opinions, conclusions and results.

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Acknowledgement

This report has been conducted in the Dominican Republic spring semester 2009. We received a scholarship from SIDA, the Swedish International Development Corporation Agency, to do our final thesis as a MFS, Minor Field Study. This kind of scholarship gives the students of a university the possibility to visit a developing country to gather information and materials for the thesis of a bachelor- or master degree.

A university in the Dominican Republic was interested of having an exchange with Jönköping University, an exchange that we became a part of through our final thesis.

It has been a new environment and culture that we had to adjust to, and it has in some cases been problematic. The process has also been complicated because of all the corruption in the country since laws and restrictions that exist are not followed.

We reserve ourselves from possible misunderstanding and misinterpretation because of difficulties with the, for us, unknown language, Spanish.

We would like to thank Martin A Abbott Zorrilla, the director of the civil engineering at INTEC (Instituto Tecnológico de Santo Domingo), for guidance through this thesis. We would also give a special credit to three students at INTEC, Eduardo Fernández de Castro, Francis Leguisamon and Roberto Sanchez who have helped us a lot to finish this thesis. Their help in translating documents, finding contacts in the building sector and always having an answer on our questions has been invaluable.

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Abstract

This report is the final thesis and the conclusion of the final project that was done during the spring semester of 2009, in the city of Santo Domingo, The Dominican Republic, West Indies by Caroline Knutsson and Kristina Myrberg.

The project is based on the field studies that are done in the investigation together with the information from interviews from the construction sites and the collected information from the research.

The focus is concentrated in an investigation about the construction techniques that are used, the building materials and the working conditions on the construction site. A study has been done of a Swedish model of urban planning with environmental objects (SAMS), made by the National Board of Housing, Building and Planning (Boverket), and successively applied in a project in South Africa. With the purpose of investigate if it is possible to apply the same model in the Dominican Republic, a review of the current environmental- and urban planning in the country has been done. Through the studies we think that an introduction of planning with environmental objectives and a development towards a sustainable and ecological society is possible in the Dominican Republic.

After field studies on the construction sites, it was relevant to discuss the working conditions and the safety for the constructers.

The thesis also deal with the waste problem, since it is a problem that is not taken care of neither in the building sector or in the society. The suggestion is to recycle and reuse more of the waste, especially all the concrete that is used in the buildings.

Sweden have come a long way ahead in the questions of sustainable housing and ecological building, to spare and reduce the effect the building sector has on the environment. This is questions of more importance than ever today, when we are seeing the effects of the climate change in the world. An investigation is done of the possibility to apply any of the methods that are used in Sweden today to make the housing more sustainable and environmentally friendly, also in The Dominican Republic. The result is some suggestions of methods and technologies that might be applicable in the Dominican Republic.

Keywords

- Building techniques
- Building materials
- Working environment
- Building ecology
- Housing
- Developing country
- The Dominican Republic
- Santo Domingo
- Environmental objectives

Sammanfattning

Denna rapport är ett examensarbete och slutsatsen av det slutliga projekt som gjordes under vårterminen 2009 i Santo Domingo, Dominikanska Republiken, Västindien av Caroline Knutsson och Kristina Myrberg.

Projektet och denna rapport är baserade på studiebesöken som har gjorts i utredningen tillsammans med informationen från intervjuerna från byggarbetsplatserna och det samlade materialet från undersökningen.

Tyngdpunkten på rapporten är en utredning kring de metoder och byggnadsmaterial som används, samt säkerheten på byggarbetsplatsen. En svensk modell gjord av Boverket, för att ta fram miljömål, och som tillämpats med lyckat resultat i ett projekt i Sydafrika har studerats. Med syftet att undersöka om det är möjligt att tillämpa samma modell i Dominikanska Republiken har en redogörelse gjorts av det nuvarande arbetet med miljö- och samhällsplanering i landet. Genom detta har vi kommit fram till att införande av miljömål och en förändring mot ett ekologiskt hållbart samhälle är möjligt på Dominikanska Republiken.

Genom studiebesök på byggarbetsplatsen ansågs det relevant att diskutera arbetsförhållandena och säkerheten för byggarbetarna.
Rapporten tar också upp problemet med avfall, eftersom detta är ett problem som inte tas omhand varken i byggsektorn eller i resten av samhället. Mer återvinning och återanvändning av avfallet föreslås som ett resultat av studien, speciellt all betong som används i byggnaderna.

Sverige har kommit långt med frågor om hållbara bostäder och ekologiska byggnader som minskar belastningen på miljön. Dessa frågor är viktigare än någonsin när vi ser effekterna av klimatförändringarna i världen.
En undersökning av möjligheten att tillämpa någon av de metoder som används i Sverige till att bygga mer hållbara och miljövänliga bostäder i Dominikanska Republiken har genomförts.
Resultatet är förslag på metoder och tekniker som kan vara användbara även i Dominikanska Republiken.

Nyckelord

- Byggnadsteknik
- Byggnadsmaterial
- Arbetsmiljö
- Byggekologi
- Husbyggnation
- U-land
- Dominikanska Republiken
- Santo Domingo
- Miljömål

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Acronyms and Word Explanations

CUP	Comprehensive Urban Plan
DGPU	Direccion General de Planeamiento Urbano
INTEC	Instituto Tecnológico de Santo Domingo
LCA	Life Cycle Assessment
MFS	Minor Field Study
NBHBP	National Board of Housing Building and Planning (Boverket)
ONE	Oficina Nacional de Estadistica
PICABUE	A method in how to choose indicators for environmental objectives
SIDA	Swedish International Development Corporation Agency
SAMS	Samhällsplanering med Miljömål i Sverige
SEA	Strategic Environmental Assessment

1 Introduction

1.1 Background

In the education of civil engineering at the School of Engineering in Jönköping, a final thesis is to be done to complete bachelor degree. This report is the result.

The environmental problems of a country are not just an issue of the specific country, but a problem that affects the whole world, since we are sharing the same earth. By sharing our knowledge and making suggestions in how to spare the earth by working with the ecological and sustainable methods country to country, we are also helping ourselves to a brighter future.

Some 20 years after that commissions and conferences about importance of creating a sustainable society were held, most of the countries in the world have agreed to the importance of these questions. Both Sweden and the Dominican Republic want to work according to the interventions of Agenda 21.

The building sector is today responsible for using a great part of the recourses of the world. If we can reduce that and plan and build in a more ecological and sustainable way, we have come a long way.

1.1.1 The Base of Environmental Laws and Objectives

The Brundtland comission
In 1987, the United Nations established a commission and it was led by the former prime minister of Norway, Gro Harlem Brundtland. The Brundtland commission defined a sustainable development as “A development that satisfies the needs of today without endanger the future generations to satisfy their needs.” The commission contains many different dimensions that are economical, social, democratic, ethical and ecological. [1]

Agenda 21
A gathering named UNCED (United Nations Conference on Environment and Development) held in the year of 1992 a conference in Rio, Brazil about the environment. Agenda 21 was at this conference made as a plan of creating a common global commitment to create a sustainable development for the 21st century. The documents of Agenda 21 start with the following requested sentences:

“Humanity stands at a defining moment in history. We are confronted with a perpetuation of disparities between and within nations, a worsening of poverty, hunger, ill health and illiteracy, and the continuing deterioration of the ecosystems on which we depend for our well-being. However, integration of environment and development concerns and greater attention to them will lead to the fulfillment of basic needs, improved living standards for all, better protected and managed ecosystems and a safer, more prosperous future. No nation can achieve this on its own; but together we can - in a global partnership for sustainable development.” [2]

One of the interventions in Agenda 21 to reach a sustainable development is that urban planning should be of high relevance. [3]

Agenda 21 is together with the earlier “Brundtland commission” the base for Sweden’s environmental laws, and ways of ecological thinking. Sweden has a vision of being the leading country in Europe of having an ecological and sustainable society. Sweden has an established work with the environment and wants to be the ideal country for ecological and sustainable development.

One of the interventions of the thesis is to investigate if there are any models from Sweden that can be applicable in a developing country such as the Dominican Republic, since they also want to work according to Agenda 21.

The thesis will be an investigation about building in the Dominican Republic, as a developing country, and an analysis of the possibility to develop sustainable and ecological methods for planning and building that is being used in the industrial countries. This thesis is focusing on housing in the capital, Santo Domingo.

1.2 Purpose

The purpose is to investigate the building process in the Dominican Republic, as a developing country and to get a picture of what laws and restrictions that the building sector is based upon. Another purpose is to see how, and if, they work with environmental objectives in the building and planning sector, and if the work can be improved or developed.

One purpose is to see what kind of buildings that is constructed right now, and which methods and materials that are used.

By looking at Sweden and how the environmental friendly and ecological way of planning and building is done, the purpose is to see if the Swedish models can be applied in the Dominican Republic.

A purpose of looking at building techniques and building materials is to see if there is any alternative that may be more appropriate than the ones that the country are using today.
The purpose of the studies of safety, waste, working environment and working conditions is to see if it can be improved.

As the study is made as a Minor Field Study sponsored by SIDA, one of the purposes is to give insight in the conditions of a developing country.

The projects purpose is to achieve knowledge of how the work of construction and housing is done in a developing country.

1.3 Delimitation

To avoid the thesis growing to big there will just be overall information about Sweden and more specific about the Dominican Republic. The overall information about Sweden presents the basics of the building sector and the environmental work, since the project is a part of the internship between a Dominican and a Swedish university. Other facts and information about Sweden is delimitated to parts that are considered as suggestions of models and techniques that could be applied in the Dominican Republic. There will only be four different field studies in construction sites in Santo Domingo. The thesis will only contain a description on what function the Management of Urban Planning have, not how the urban planning of the city looks like.

1.4 Disposition

The report is based on a comparison between the Dominican Republic and Sweden. By knowing how to build in Sweden and what laws and restriction there are, it is possible to see how the work is done in another country and what we can learn from each other.

One chapter contains information about the building process in the Dominican Republic, how they build and with what materials. There is some background information about the country, about the building laws and regulations, environmental work and about the waste. This chapter handles the field studies made during the time spent in the Dominican Republic.

The following chapter is about Sweden and presents the basics of the building sector and the environmental work, other fact and information about Sweden in this chapter are considered as necessary information for suggestions of models and techniques that could be applied in the Dominican Republic.

The thesis ends with a discussion concerning the possibility of applying the model of SAMS in Santo Domingo for the development of a more sustainable society, and also discussions about the building techniques, materials, waste and about working environment and environmental objectives. The last conclusion is about if there is something applicable from the Swedish way of building to the Dominican.

1.5 Method

To collect information to this final thesis the methods have been internet, books, e-books, reports, interviews and information from INTEC (Instituto Tecnológico de Santo Domingo) and two month of studying in Santo Domingo.

1.5.1 Field Study

To get a bigger insight of the building in the Dominican Republic, visits were made at several construction sites. A study of the building process was made concerning which building materials that were used and with which method and techniques. The construction site as a working place was inspected in purpose to see what working conditions were like.

1.5.2 INTEC (Instituto Tecnológico de Santo Domingo)

INTEC University contributed with a lot of help; among others three students were helpful by providing contacts with all of the engineers and authorities, translating the Spanish documents and how to collect some of the information in the best way. The contact with the professors on the university has also helped to get a picture of the situation of the building sector in Santo Domingo.

1.5.3 Interviews

A number of interviews with people in the Dominican Republic are done. Most of them with engineers and architects, that we met on our field studies but also professors and students at INTEC. This has given a good overview of how the building situation looks like in the country. By discussing the building procedures with a lot of people a lot of different approaches and thoughts have been collected. All the interviews are of discussing type. It has been a variation of different kind of people in the interviews, young and old, students and well-educated and through that we can try to get our own opinion.

2 The Dominican Republic

This chapter contains information about the Dominican Republic and is written to present the building procedure in the country. The subheadings below are the parts that have been studied to find how to develop a sustainable building process.

2.1 Facts of the Country

The Dominican Republic is located in the Caribbean, West Indies. The country has a total area of 48 422 km² in which it covers two thirds of the island of Hispaniola; the other part belongs to Haiti. The spoken language is Spanish.

The total population of the Dominican Republic has a number of 9.5 million (2008). About 4 millions of the population lives in the capital, Santo Domingo, located on the south coast of the country.

Figure 1 Maps over the Dominican Republic

The island of Hispaniola was the place that Christopher Columbus first arrived to and explored when he “discovered” the new world, on his first journey in 1492. The whole island stayed Spanish until 1692, when one third of the island was taken over by France; the part that later would become Haiti. The Dominican Republic was declared as an independent state in 1844.

The country has gone through long periods of dictatorship and it has also been occupied by USA during a period of time, as a result of inability of paying their growing external dept. Today the state of the government is a presidential republic led by the current president, Leonel Fernández.

The country is very corrupt and it has a big problem with the electricity supply and also the illegal drug trade. Another big issue is the tense relation to Haiti, which is the poorest country in Latin America. A large number Haitian people are trying to pass the borders to live in The Dominican Republic, most of them as illegal emigrants.

There are great differences in the economic situation of the citizens in the Dominican Republic. The country is among the poorest in the West Indies with widespread

poverty and large social disparities. [4] The richest tenth part of the people receives 40% of the total revenue of the country. 25% of the population is counted as poor. [5] The BNP (nominal) was in 2004: 18.5 billions US dollar and the BNP per capita (nominal) 2190 US dollar. [6]

The climate of this region and this country is tropical maritime. It has a small variation in temperature according to the seasons. As for the rainfalls there is a big seasonal variation, which causes occasional flooding. The Dominican Republic is located in the middle of the hurricane belt which makes the country a subject to severe storms from June to October. [7] [8]

2.2 Building Process

To see how the procedure of the building process is looking and to see how much the working environment and labor is affecting the building process, investigations has been done in these matters which is declared in the subheadings of the way they build and construct, the building codes, the working environment and the labor in the country.

2.2.1 Building and Construction

The most common construction process in the Dominican Republic is that a contractor is buying a site for the construction. The normal thing for the contractor is to hire an architect and engineer to produce the documents and drawings for the construction, if the professionals do not already exist within the company.

Economy is always the determinable issue about building in Santo Domingo. In every decision the cheapest alternative, that can bring the most money, is the one that is selected. The sites for sale in the central parts of Santo Domingo are very expensive. For that reason the contractors are making the constructions as multistory houses, to get as much money as possible.

Basically all the houses are made in concrete, with the technique of masonry with concrete blocks. This concerns all the walls, load bearing or not and no matter how many stories high the building is. The reason for entirely using concrete blocks is that it resists the great powers from the hurricanes that the buildings are being exposed for. It also increases the resistance by an earthquake that is a considering threat in this region. The economy is the greatest reason to why the construction technique is being used though.

From a Swedish point of view, this would become a time-consuming and expensive technique. The reason to why it still is the cheapest method is because of the low wages of the construction workers. A large number of legal and illegal immigrant Haitians are working in constructions were they are being used as underpaid labor. To keep the costs down of proper equipment and machines; the work is instead done by manual labor.

Because of the deep-rooted corruption the contractors are easily using bribes to avoid inspection of the level of the wages. Bribes are also used to prevent inspection of the working conditions and safety for the workers at the construction sites. [9]

2.2.2 Building Code

In the Dominican Republic they use the same building code as in the rest of America, ACI 318 and ASTM. [10]

ACI318
The Building Code Requirements for Structural Concrete, ACI 318, covers the materials, design, and construction of structural concrete used in buildings. The Code also covers the strength evaluation of existing concrete structures. [5]

ASTM
ASTM (American Society for Testing and Materials) is a standard for a wide range of materials, products, systems, and services. [5]

2.2.3 Working Environment

The working environment in the Dominican Republic is tougher than the Swedish. This has been experienced by field studies on different construction sites done during the project. There are hard days with a lot of heavy lifting in a burning sun and it does not exist much safety on the construction site. Some workers have construction helmets, but most of them do not. The scaffolds are made of wood or steel and many times you can see a construction worker trying to keep balance on narrow boards 10 levels above the ground.

Figure 2 Unsafe scaffolds

In the constructions that have been visited there has not been anything in front of the elevator pit, just a hole that is easy to fall down into in the shady light, and in the same way all around the building, no fences or nets. Such things as hearing protection and safety spectacles do not exist. This is just a few issues that are very important on a Swedish construction site.

There is an institution named Administrador de Riesgos Laborales - ARL (Administrator of Working Risks). The law says that every company has to pay some percent of the monthly payment of the worker to this institution, to make sure the worker has a backup income if the person has an accident during the working period. This percent varies from 1 to 1.30% depending on the type of job. This institution receives all the cases and reports of accidents about all the sectors. The number of accidents in the construction sector that was reported to the ARL during the year 2008 was 889 cases. 8, 3% of the total amounts of accidents. [11]

2.2.4 Labor in the Dominican Republic

The law prohibits child labor and forced labor but reports shows that this occurs. Child labor is a particularly serious problem, especially among children with Haitian background. The high rate of unemployment is forcing the children to contribute to the family's livelihood. About 90 percent of the children start to work before the age of 14.

The massive illegal immigration from the poor neighboring country Haiti has led to serious problems of immigration policy. Many Haitian workers tries to find a job in the Dominican Republic because it’s better salary and better work conditions than in their home country. The number of Haitian migrant workers, with or without legal status is estimated at nearly one million people.

Many of these immigrant workers work at a construction site and under the same conditions as the Dominicans, but many are working under different conditions. Some don’t have the same rights and some doesn’t even get paid for their work. In some cases when the building is almost finished the contractor tells the illegal workers that there will come an inspector. This means that they must leave, and most of the time without their payment.

Some Haitian workers stay both day and night at the construction site to save the money instead of renting an apartment. Therefore, in many constructions you can find clothes that are drying in the sun or mattresses on the floor. [12][13]

2.3 Housing

To gain information of the situation of housing is like in the country a study over what sort of houses that exists is done. The studies are mostly located in the city center of the capital that is dominated by apartment houses. Part 2.3.2 gives a presentation in how the apartments look like that is build in the city of Santo Domingo today. The part handling Urban Planning 2.3.3 is made to se how the state is working with the urban planning in Santo Domingo in the present of time. The reason of this study is to see if a change is necessary to plan and build for an improved environment in the city.

2.3.1 Statistics - Houses

To get a picture of what kind of different houses that exists in the Dominican Republic and what differences there are between the whole country and the city centre the following statistic is relevant.

This statistics that is made over the buildings in The Dominican Republic by the Oficina Nacional de Estadistica, ONE (2002) (the national office of statistics) shows that the houses are divided into 7 different kinds.

Independent houses
These are the most common houses in the Dominican Republic and represents 80% of all the buildings in the whole country, and 62% of all the buildings in the central part of Santo Domingo.

Independent houses are generally separate and with direct access from the street. They are generally exclusive and occupied by one or several people in a family.

Apartments
The major topic for this thesis is concentrated on apartments because this is the houses that are being constructed most in the capital right now. It is only 6.8% of the houses in the whole country but 24% of the houses in central part of Santo Domingo.

Apartments is a part of a building that has an independent entrance from a hallway or stairway of common use that offers direct access to the street.

Part of a room (or back part)
Unit of a group of houses generally located at backyards.

Barrack
A barrack is a type of bunkhouse with common roof and can exist in "bateyes azucareros" (Rural community near a plantation of sugar cane that whose economy comes from working in those plantations) or is a temporary construction destined to victims of natural disasters. These houses are unusual in the city, only 856 barracks compares to 26,009 in the whole country.

Place that was not supposed to be habited
These houses are located on places that was not originally planned to be habited by people, but is being used for that purpose anyhow.

Houses in construction
This is a house that has a part built and can permanently or provisionally hold people. This is a big problem in the Dominican Republic, people start to build houses and then they cannot afford to finish them. Therefore, everywhere there are unfinished constructions.

Houses built by waste materials and improvised houses.
Most of these houses belong to illegal people from Haiti. The people come to this country to get a job, and they build a house of the things they can find, mostly wooden and zinc pieces. These houses are always destroyed in the hurricanes. Figure 3 shows that this improvised homes is only 0.9% of all the houses in Dominican Republic. [14]

Total of Dominican Republic	**Total**	**Occupied**	**Vacant**
Independent houses	1.958.030	1.785.288	172.742
Apartments	166.628	146.641	19.987
Part of a room	147.859	138.330	9.529
Barrack	26.099	21.962	4.137
Place that was not supposed to be habited	16.379	8.115	8.264
Houses in construction	65.058	24.007	41.051
Houses built by waste materials and improvised houses	43.656	40.928	2.728
Others	21.606	15.878	5.728
Total	**2.445.315**	**2.184.149**	**264.166**

Figure 3 Statistics over houses in the Dominican Republic [14]

Santo Domingo (city)	**Total**	**Occupied**	**Vacant**
Independent houses	164.993	156.648	8.345
Apartments	64.770	57.757	7.013
Part of a room	26.131	25.043	1.088
Barrack	856	786	70
Place that was not supposed to be habited	1.256	716	540
Houses in construction	2.696	961	1.735
Houses built by waste materials and improvised houses	3.924	3.730	194
Other	1.852	1.552	300
Total	**266.478**	**247.193**	**19.285**

Figure 4 Statistics over houses in Santo Domingo [14]

The whole region of Santo Domingo	Total	Occupied	Vacant
Independent houses	545.548	515.112	30.436
Apartments	107.109	96.122	10.987
Part of a room	65.113	62.377	2.736
Barrack	4.888	4.552	336
Place that was not supposed to be habited	3.813	2.449	1.364
Houses in construction	18.179	7.925	10.254
Houses built by waste materials and improvised houses	12.798	12.301	497
Other	6.275	5.293	982
Total	**763.723**	**706.131**	**57.592**

Figure 5 Statistics over houses in the whole region of Santo Domingo [14]

2.3.2 A typical Dominican Apartment Plan

This following picture is a typical plan over a middle class house in Santo Domingo. A visit to the specific house has not been done, but to houses that are comparable to this one. The apartment house is an 8 levels high building with two apartments on each level.
The special layout with this plan comparing to normally Swedish houses are that there must be a special room for the housekeeper. This room must be located so the housekeeper has access to the kitchen and the laundry area. The only regulations about this room is that there must be space enough for a bed, but the bed do not have to be more than 1.60 meters. There must be a toilet and shower area. In most houses there are no doors to the toilet and shower area. In many cases, the room is in the middle of the apartment and does not have a single window.

It is very common in some of the buildings that the elevator leads directly up to the apartment without a stairwell and in these houses there is another elevator just for the housekeeper.

The bathrooms are usually placed inside the bedrooms, and in some cases one bathroom in each bedroom. Comparing to the normal Swedish house this is quite much. See following figure.

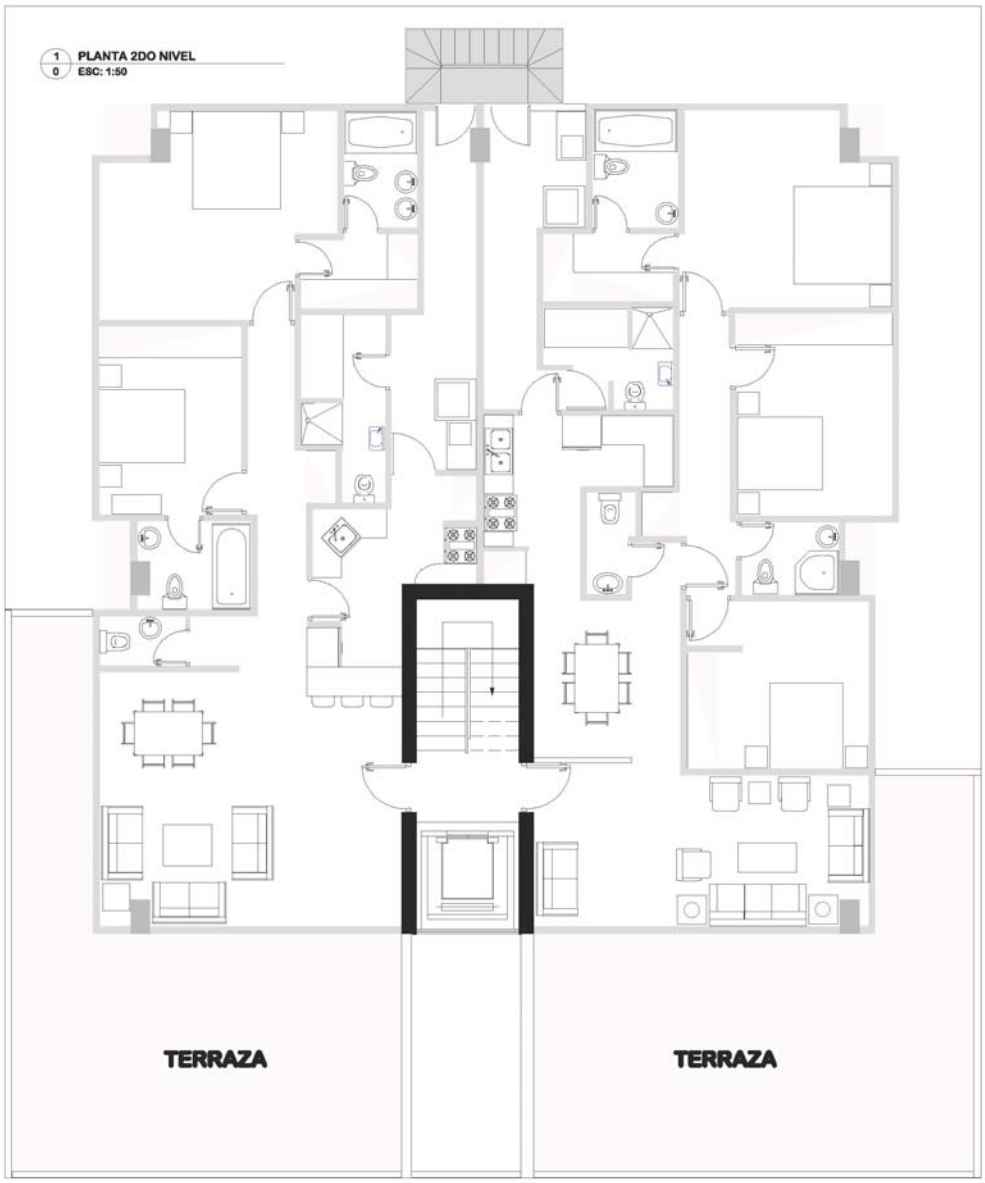

Figure 6 Apartment plan [15]

2.3.3 Urban Planning in Santo Domingo

The management of urban planning in Santo Domingo is a governmental department named DGPU (Direccion General de Planeamiento Urbano) Their function is to regulate the urban growth and to be a consultative and advisory body. There is a law which states that DGPU is going to have the function of working with two general aspects; Administration and control of the city and Planning control of urban development.

From their webpage (www.adn.gob.do) it is possible to read that to work with the two aspects DGPU should have several specialized sections for its operations. The four existing sections are:

1. Urbanism
"Its main function is to control the use of urban land and the condition of isolation, housing, aesthetics and other functional aspects of housing and buildings. This section will provide, in accordance with laws, regulations and planning requirements up to date, the permits related to land use, changes in the land use, preliminary and construction projects, reconstruction, expansion, remodeling, and demolition of buildings and land within the National District. These permits shall be signed by the Director or Deputy Director"

2. Handling of Plans
"This section is responsible for processing all documents relating to the approvals of land uses and buildings…"

3. Control and Inspection
"The role of this section is to maintain control of the city, conducting regular inspections in different urban areas to detect any improper use of public spaces, illegal construction, alteration of existing structures without proper permits, among others."

4. Surveying
"Its functions are to develop and maintain an urban registry in coordination with the General Management of National Surveying, (Dirección General de Catastro Nacional) maintain a registry of municipal property and green areas, verify the land registry documents that are submitted to the Director."

There is no work considering sustainability or the environment included in the department of DGPU, this is separated to a different department of Environmental Management. [16]

2.4 The Environmental Work in the Dominican Republic

An investigation is done over what has been done in the country to work with environmental questions in the past and how they are working with it today. The information is gained with the purposes to see if the environmental work needs to be developed and to investigate if Swedish models of how to work for a sustainable environment could be adaptable in The Dominican Republic.

2.4.1 Environmental Management

The Dominican Republic has a mission and a vision for the future work with the environment. This can be a good start to develop environmental objectives that are more detailed.

The Mission:
"To implement a comprehensive state policy for the conservation, protection and regulation of the management of natural resources and environment for sustainable development of the Dominican Republic"

The Vision:
"Develop a policy based on cooperation and strategic alliances between government, communities and business, to engage all public and private actors involved in environmental management and natural resources. To create a sustainable development that ensures a quality of life for present and future generations". [17]

There is a mind and a will to work more with the environmental issues and to become a more sustainable society. Several projects with international relations have been done for the progress of these matters.

United Nations writes a report [18] about different programs in the Dominican Republic, concerning strategies, priorities, plans and policies for a sustainable development. The report summarizes the different programs and their objectives. Some of the programs are an important base and a seedbed for turning the building sector more sustainable. Short descriptions of such programs of relevance are the following;

Programa 21 Nacional, is a program for “the National Commission to follow up the commitments with the United Nations Conference on Environment and Development and to generate a participative process between the public and private sector to allow to articulate the social, economic and environmental dimensions for the sustainable development.”

National Strategy of Environmental Education, “This was developed in 1992 with the objective to put in practice the Law 295-85, (that does obligatory to introduce in the educative plans the conservation of the natural resources and the atmosphere) and for the formulation of a Plan of National Action on Environmental Education. The

strategy contains a tending assembly of actions to contribute with the formation of conscious and defender citizens of its environment"

Project for Environmental Politics, "This project was formulated with the objective of establishing the bases for an improved environmental handling in the Dominican Republic, through a process of learning and participation, defining reforms of environmental policies and elaborating a *National Program of Environmental Management."*

The project was financed by a loan from the World Bank. The document of the World Bank [19] states the background, the objectives and the result of the project. It was started after a request in 1997 from the Government of the Dominican Republic for assistance in coordinating, consulting and improving environmental management. The project did among others put effort on a new Environmental Framework Law and also to strengthen the Institutional Capacity for Environmental Planning and Management. Both of these projects were rated as highly satisfying.

The Environmental Management Authority is the organization that is given the responsibility for "preventing the environmental pollution and to implement the power to enforce the law, standards and environmental regulations in the territory of the National District."
According to law the Environmental Management is going to work with the following general functions:

- Develop standards for the preservation of the environment and natural resources of the municipality based on the general fundaments contained in the law.
- The creation of civic education programs for management and treatment of waste
- Give a technical opinion about projects that are submitted to the City Council and which requires studies and evaluations on environmental impact.

Elaborate programs for utilization and use of public spaces such as city squares and green areas. [20]

2.5 Materials, Energy and Waste

To get a picture over the common building materials of different types of houses in the country, statistics has been studied and counted. The most common material; concrete is handled in part 2.5.2 with information of the problems and the benefits of the material. Part 2.5.3 is investigating how the large amount of sun hours makes it possible to gain energy from the sun.

2.5.1 Statistics – Materials

The following numbers is statistics from the year of 2002 done by Oficina Nacional de Estadistica, ONE (the national office of statistics) in The Dominican Republic. It shows the most used materials in outer walls, roofs and floors in the different types of houses in The Dominican Republic. Since the investigation is concentrated in the capital, Santo Domingo and more specific the central parts of the city, the statistics is also handling this area. [14]

The study looks specifically at the house types of **apartment houses**, since that is where most of the field studies been. **The independent houses** are the most common type of houses in the country and it is therefore interesting to see what kind of materials that is used. The study is also handling **houses under construction**, to see if it is any change of the materials today compared to earlier built houses. Finally, it handles the most common material use, independent of what house type it is.

The different materials that ONE is keeping statistics over are the following:

Walls
Concrete or concrete blocks

Wood, most common is pinewood

Palm wood (*tabla de palma*) wood from palm tree's

Tejamanil, thin wooden shingles that is being braved or put so they are overlapping each other. Used mainly by poor people.

Figure 7 Tejamanil

Yagua, Clapboards or stripes of palm bark taken from the royal palm. Widely used for construction materials, particularly as siding for peasant houses. It is used in Hispaniola to tropical Central America. Used by very poor people. [21]

Other, any other sort of building material for walls

Roofs
Concrete, Zinc, Asbestos concrete, Yagua (see above) *Cana* (Palm leaves) *and Others*

Floors
Granite-marble-ceramic, Mosaic, Concrete, Earth, Wood and Others

The numbers of statistic concerning the total housing in The Dominican Republic is calculated to see the variation of material use in the different type of houses. The following tables are showing the percent of which material that is used in what type of house in the year of 2002

Material ***Walls***	**Independent Houses** (%)			**Apartment houses** (%)			**Houses under construction** (%)			**Total number of occupied houses** (%)		
	DR*	SD**	SDC***	DR	SD	SDC	DR	SD	SDC	DR	SD	SDC
Concrete, concrete blocks	63.3	78.6	86.96	99.3	99.7	99.8	86.6	88.4	87.9	66.5	80.7	88.83
Wood	26.2	18.5	11.87	0.7	0.3	0.2	10.6	10.9	11.2	24.5	17.8	10.3
Palm wood	7.4	0.8	0.26	-	-	-	2.4	0.6	0.5	6.4	0.7	0.22
Tejamanil	0.6	0.07	0.03	-	-	-	0.2	0.09	0.03	0.5	0.07	0.02
Yagua	0.4	0.03	0.02	-	-	-	0.2	0.04	-	0.3	0.03	0.01
Other	2.1	2.0	0.86	-	-	-	-	-	-	1.8	1.5	0.62

Figure 8 Statistics over materials in walls [14]

* The Dominican Republic
** Santo Domingo
*** The center of Santo Domingo

Concrete and concrete blocks are the most common wall materials in all the three chosen categories of houses. Especially in the center of the capital there are a lot of concrete walls in the high houses that are typical for the big city.

Wood is the second most common material for the independent houses. It is rare to use wood for constructions in apartment houses because the availability of timber is not big in the country so they need to import the wood.

In the countryside there is more walls made of *Palm wood, Tejamanil* and *Yagua*. Totally 6,4 % of the walls in the country is made of palm wood.

Material ***Roofs***	**Independent Houses** (%)			**Apartment houses** (%)			**Houses under construction** (%)			**Total number of occupied houses** (%)		
	DR	SD	SDC	DR	SD	SDC	DR	SD	SDC	DR	SD	SDC
Concrete	26.8	48.5	54.393	94.3	96.6	97.756	28.5	37.07	39.44	31.2	52.9	61.89
Zinc	69.9	49.9	44.04	4.5	2.5	1.492	68.9	60.9	58.58	65.6	45.6	36.68
Asbesto concrete	1.2	1.3	1.22	1.2	0.9	0.75	21.6	1.78	1.66	1.3	1.2	1.14
Yagua	0.7	0.004	0.003	-	-	-	0.3	0.004	-	0.6	0.04	0.02
Palm leaves	1.1	0.006	0.003	0.03	0.001	0.002	0.3	-	-	0.9	0.006	0.003
Other	0.3	0.2	0.31	-	-	-	0.3	0.21	0.31	0.3	0.2	0.26

Figure 9 Statistics over materials in roofs [14]

When it comes to roofs, the *concrete roofs* is the one that is being used the most in the city comparing to the countryside where the roof of zinc is the most common. There are still some houses that has roof made of *palm leaves* or *yagua*, this material is not very resistant to rain or sun so it needs to be replaced after just some years.

Material ***Floors***	**Independent Houses** (%)			**Apartment houses** (%)			**Houses under construction** (%)			**Total number of occupied houses**(%)		
	DR	SD	SDC	DR	SD	SDC	DR	SD	SDC	DR	SD	SDC
Granite, marble, ceramic	8.8	17.2	21.5	42.9	48.2	58.0	3.1	4.1	5.4	10.5	19.8	28.0
Mosaic	11.1	16.6	21.6	36.9	34.5	31.9	3.5	4.9	7.2	12.3	17.9	22.9
Concrete	71.9	63.3	55.5	20.2	17.3	10.1	71.7	74.3	74.0	69.8	59.7	48.1
Earthen	7.6	2.3	0.8	-	-	-	20.6	15.7	12.0	6.9	2.1	0.6
Wood	0.3	0.2	0.2	-	-	-	0.1	0.2	1.1	0.3	0.2	0.1
Other	0.3	0.3	0.4	-	-	-	1.0	0.7	0.3	0.2	0.2	0.3

Figure 10 Statistics over materials in floors [14]

The material of the floor is mostly made of concrete. It is the least expensive material because when the foundation is cast, the floor is already finished. Marble is a more expensive material and is used in the more luxury homes in the capital. There is 28 % of the houses in central Santo Domingo that has floors made of marble or similar, comparing to 10,5% in the whole country.

It is easy to see the differences between rich and poor households in the capital and in the countryside. In central Santo Domingo there is only 0,6% that has earthen floor but the statistics for the whole country shows that up to 6,9% of the houses have earthen floors.

2.5.2 Concrete

Concrete is a material that comes from rocks and stones and finally returns to rocks and stones. The limestone reserves are globally unlimited in practice and there is also a lot of granite. The concrete construction has a long life and can be recycled to 100%.
This indicates that concrete is a sustainable, environmental friendly material from the nature. [22]

Concrete in the Dominican Republic
Concrete is the main material that is being used in the Dominican Republic, and it is hard to find a comparable material that has the same advantages as the concrete. It is a heavy material that keeps out the heat and is stable towards hurricanes that are common in the country and earthquakes that may occur.

There are different ways to build in concrete, in the Dominican Republic there are often cast concrete in the columns and beams and concrete blocks in the walls.

In the slabs, they have started to use a technique where they cast in pieces of foam in the bottom of the slabs. They put a thin layer of fine cement all over the sealing to cover the foam. The reason for this is to make the structure less heavy. This technique lowers the use of concrete, but it creates some issues with the stability in the sealing. It is also questionable if the thin layer of fine cement is preventing the foam from melting in case of a fire.

2.5.3 Sun Energy

Today most of the water is heated by gas or electricity in the Dominican Republic, but still the majority of the houses in Santo Domingo do not have hot water at all. There can be a lot of electricity and gas to save by installing solar collectors on the houses as a source to heat the water. At this time, the solar collectors and solar cells have not come so far in the development and are still very expensive.

Solar Collectors
A solar collector raises radiation energy to transfer it to a heat carrier for example fluid or air which transfer the heat to an accumulator tank.
The heat is restored here and can be used for hot water.
One m^2 of a solar collector can today produce about 770 kWh /year and can produce heat during 25 years. [37]

Figure 11 There are a few solar collectors in Santo Domingo

Solar Cells
From the middle of 1990s, the production of solar cells has increased. Calculations show that in about 30 years, 50 – 70% of the world's energy consumption can be supplied with energy directly from the sun. A big part of the population already lives in a part of the world where the sun energy can be lucrative.

A breakthrough for the solar cells would be if it is possible to store energy with hydrogen gas as an energy carrier.

One problem with solar cells in the warm countries is that the efficiency reduces with a half percent for every increasing degree. This can be solved with aluminum stripes on the back of the cells to remove the heat. [1][23]

2.5.4 Waste

There is no recycling or reusing in the building industry in the Dominican Republic, all the waste from the building materials collects in a big container, which is brought to the dump yard by the municipal authorities. In the dump yard there is some reuse of concrete blocks for example. The poor people works on the dump site and sorting the waste to be able to sell it again.

Figure12 An area to collect the waste from the construction site

The only environmental restriction in the Dominican Republic is about waste, where to put it and how to collect it. It is prohibited to throw the waste on the street and building materials must be collected in special containers. This law among others seems not enough. [24]

Ms. Catterin Cattafesta from the International Resources Group**,** presented the results of a national study on environmental services on the UNEP-UNCTAD Workshop on Post-Doha Trade and Environment Issues in Santo Domingo, Dominican Republic, 21-22 July 2005.
"She described the main environmental service sectors in the Dominican Republic, and discussed the Millennium Development Goals (MDGs) and what their attainment would imply in terms of improving environmental services in the Dominican Republic, such as water sanitation, waste management, etc. She noted that liberalization in the waste management sector could lead to better quality only if coupled with a clear consideration of the social impact of the liberalization and an adequate system of incentives in order to get the private sector investing in recycling and re-using of waste."

There are many things to combine to have a functioning waste management. And as Cattafesta describes, it has a lot to do with recycling and re-using of waste. [25]

Statistic Waste
Statistics from year 2002 shows that the waste is thrown in different places. In Santo Domingo the solid waste collection services are 95% privatized. It is strange that the country has statistic over where they put their waste when it looks like this. 3.7% throws the garbage in the river and 23.7% burns their waste.
52.7% of the people living in independent houses have their waste collected by the city council and 3.4% of private company. This means that 43.9% of the waste from independent houses goes to places that are not registries as legally dumpsites.

98% of the solid waste is deposited in open dumps. Open-air disposal in dumps can create serious environmental health risks and groundwater contaminations.

This statistics shows that the waste management is not working in any sector at all of the waste management, so it is not just the waste from the construction site that is the environmental problem. [26]

2.6 Field Studies

To gain knowledge in how construction of housing is done in the Dominican Republic a couple of construction sites were visited to interview the engineers and architects and to take pictures. A study of building materials, building techniques and methods was done to deepen the knowledge of the work at a construction site in the country.

2.6.1 Field Study 1 and 2

090224 and 090311
Field studies were done on two construction sites in Santo Domingo made by the same company, L&M Heyaime & Partner. One house is in the beginning of the building process and the other one is almost finished.

One of the houses is a 16 level high building and the other one is with 10 levels. It is build by L&M Heyaime & Partner with the architect Miguelina Heyaime who is also the vice president in the company. The buildings are a high-class housing, and are almost the same, just different numbers of levels.

In the 16 level high building there is 14 apartments of each 470m^2, 4 apartments on 235m^2 and 2 unique pent-house in two levels on 470m^2.

There are two levels of parking under ground and each apartment has between 2 – 4 parking spaces.

At the moment of the visit, the framework was cast and they had begun to build up the walls of concrete blocks. The frame of the building is made of cast concrete columns and beams and has no load-bearing walls. The slab is concrete with foam to get a lighter construction, about 15cm solid concrete and 20-25cm of concrete with foam.

After the cast is done, they start to build up the walls with concrete blocks and join them together with mortar made of rough sand. This takes a long time and many workers work hard to complete a whole house.

Figure 13 Concrete block wall

The balconies are cast together with the slab and have a wall around of concrete blocks. They use two different kinds of sand for the concrete. One more rough to the columns and beams and one finer for the top layer of the walls to make the surface smooth.

The pipes for electricity are made of PVC plastic, except from the electricity for the elevators that is in carbonated steel and is earthed.

The water to the bathrooms goes thru pipes of polypropylene while the drainpipe is made of PVC-SDR26.

The windows will be aluminum sliding-windows and it is assembled in the wall with just screws and plugs and has a draught excluder of silicon. This can make the house compact comparing to the flip-windows that is very common.

The door is made of mahogany, the most common materials for doors in the Dominican Republic, but it is also the most expensive. The wood is treated against termites. The door case is made of the same wooden kind and it is put in place with glue mixed with sawdust.

The building has two stairways. One inside that is connected to the elevator and one emergency exit on the outside of the building.

Figure 14 Scaffolds

Outside they have scaffolds made of wood. This wood is reused four times before they throw it away. The building also has one small crane, which has a maximum load of eight concrete blocks that serves the whole building. They are not using a lot of electricity at the construction site. They just had one small lamp, and the small crane. [13][9]

Figure 15 Building crane

2.6.2 Field Study 3

Figure 16 Facade Torre Shalom II

110309
A field study was made to the construction site of Torre Shalom II located in the eastern part of central Santo Domingo. This construction is a 10 story housing project with two stories of parking decks. The apartments have sizes of two and three bedrooms.

The local engineer of the project, Amel Rosario, showed us around at the construction site and gave an interview about the construction.

This project started the construction in December 2008. At the time of the visit they were working at the basement which will become the lower parking deck.

Figure 17 Construction site, lower parking deck

The structure is a column-beam construction that is cast in place. For the structure and the base ground industrial concrete is being used. It arrives in concrete cars with a capacity of 7 m^3.

The slabs are cast up on the beams with a height of 250 mm. Pieces of foam with a size of 500*500*150 mm are placed in the bottom of the mold and concrete is cast around it and with a layer of 100 mm. up on it. The foam is later covered up by a thin layer of fine cement 5-10 mm thick.

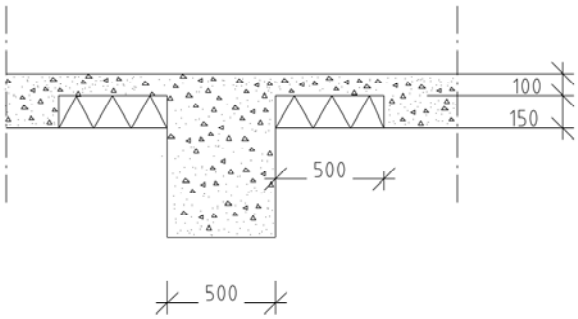

Figure 18 Slab with foam

The building process at this project followed the procedure that the contractor bought the site. Architects and engineers within the company of the contractor produced the drawings and documents for the building.

A subcontractor is hired for the carpentry, and in his turn got carpenters employed for the work. The wood that is used for the construction is provided by the subcontractor himself and not by the contractor. If the contractor buys the wood, the cost will be deducted from the subcontractors payment. The reason for this is that the wood can be used for molds in other constructions that the subcontractor will be working with in the future.

A subcontractor is also used for the steel work. The difference is that the company of the contractor provides the steel.

The scaffolds are at this construction made of steel and they are hired in for the project.

The sewage water from the apartments will be collected in a tank where the black water is separated from the gray. The solid parts will be collected by a sewage lorry, and later thrown away. The gray water is going from the tank to a municipal sewage plant.

In the basement there is also a tank for the freshwater for the apartments. This water will be delivered to the building and refilled 2-3 days a week. The water tank has a volume of 50.000 gallons.

The workers on this construction site are both Dominicans and Haitians. The Dominicans are generally being hired as carpenters and steel workers while the Haitians are mostly doing the harder kind of work and they are getting less paid for their work. According to engineer Rosario there is a governmental law regulating the conditions and fair payment of the workers but this law does not apply to foreigners in the same outreach.
A shed was build at the construction site. It was working as a construction shack and also as a home for seven of the Haitian workers. They had made the choice to live there themselves, to save the money from the salary, not being required to pay rent for an apartment. [15]

Figure 19 Home for the Haitian workers

2.6.3 Field Study 4

090202
A slum area that is located next to a very contaminated river was visited. This field study was made to see another part of the country outside the concrete cities. The people who live there do not have the permission to stay there, but they put up their houses there anyway. The houses are sheds made of wooden walls and roof of zinc and just contain one room, also named as barracks in the statistics. The floor is made of clay and the houses do not have any water or sewer. Some houses have the ground built in concrete blocks. These houses are built next to each other with just a small path that separates them.

Figure 20 Sheds in the slum area

The largest problem in this area is the flood that comes every time it rains. During the rainy season, many houses are flushed away in the big floods and the people are forced to take cover in a school nearby. This leads to that the classes needs to cancel because the classrooms is occupied with people.
Another problem is the contaminated water that contains many bacteria that causes a lot of diseases and many of the children is playing in the water and get sick.

There is a project going on right now which has the goal to move this people to a safer place further away from the river. These houses have better standards and help the people to get a more decent life. Right now the project stands still because there is not enough money.

3 Building in Sweden

Subheading 3.1 and 3.2 contains overall information about building in Sweden, it is written to present the basics of the building sector and the environmental work. The reason is to give Dominicans an insight of how this work is done in Sweden, as a part of the internship between a Dominican and a Swedish university that this report is a part of. The following subheadings; 3.3 - 3.5 in this chapter are holding fact and information that is more specific. The reason is to present models and techniques that is used in Sweden and considered as possible to apply also in the Dominican Republic for a development of the building technique and for a more sustainable society.

3.1 Building Process

3.1.1 The Planning and Building Act (PBL)

The Planning and Building Act (PBL) is a law that regulates the planning of ground, water and construction. The Act contains for example comprehensive plan, detailed development plan, building permits and so on.

The requirements according building is shown in the detailed development plan, which should follow the intentions of the municipal comprehensive plan. [27]

3.1.2 Building Regulations (BBR)

The Building Regulations (Boverkets Byggregler) is a collection of rules and guidelines that concerns Swedish buildings. The building regulations contain requirements and guidance for the building`s design in aspects of bearing capacity protection, fire, hygiene, noise protection, safety and energy efficiency. [27]

3.1.3 The National Board of Housing, Building and Planning (NBHBP)

The National Board of Housing, Building and Planning – Boverket – is the central government authority for planning, the management of land and water resources, urban development, building and housing under the Ministry of the Environment. NBHBP monitors the function of the legislative system under the Planning and Building Act and related legislation and proposes regulatory changes if necessary. To ensure effective implementation NBHBP also provides information to those engaged in planning, housing, construction and building inspection activities. [27]

Areas of activities
In the field of planning and urban development, NBHBP is responsible for ensuring that ecological, economic, cultural and social aspects are taken into account in planning. The focus of planning is increasingly turning to regional development, sustainable urban development by introducing new planning methods.

In the field of building NBHBP is responsible for developing design and building regulations and other regulative measures for construction, e.g. for certification of persons, Swedish type approval and CE-marking. The Board supports the development of cost and energy efficient, healthy and sustainable buildings as well as accessible public spaces.

In the field of housing, NBHBP´s task is to promote the availability of affordable good-quality housing. NBHBP is responsible for ensuring efficient and consistent administration of government subsidies for investment in housing and improved energy systems. NBHBP makes long-term analyses e.g. with regard to exclusion and availability of housing in different parts of the country.

NBHBP is working with a large number of environmental issues, which roughly can be divided into four areas [27]:

1. Environmental quality objective A Good Built Environment.
2. Environmental issue of spatial planning and management of land and water and buildings, including the project SAMS - planning with environmental quality objectives.
3. Building sector responsibilities with regard to the ecologically sustainable development.
4. Internal environmental work.

3.1.4 Working Environment

The working environment concerns things like machines, protective clothes, staff management and education.

The construction business is one with the most injuries in Sweden. The number of occupational injuries has also increased between 1997 and 2001, especially musculoskeletal disorders and accidents with falls.

Shortcomings in the work environment are often due to insufficient knowledge of the working environment, missing in planning, poor coordination of projects and too short construction times. For example, the case risks, unsuitable postures and heavy lifting are not sufficiently prevented.

Swedish Work Environment Authority is an authority under the ministry of industry, employment and communications. They are responsible to develop rules for how a good working environment should be. If we follow these rules, everyone should be able to work without getting sick or injured. The Work Environment Authority has inspectors that check the workplaces so that they live up to the requirements.

There are two major laws that control the work environment at a building site. It is the Working environment act and the working hours act.

The working environment act says that:

1 Chap 1§
"*The purpose of this Act is to prevent ill-health and accidents at work and generally to achieve a good working environment.*"[28]

The law is not just about preventing accidents and unhealthiness but also how to create a work with good contents.

The Work Environment Act passed by the parliament in 1977 and took effect on 1 July 1978. It has been amended several times since then, and the last one is the wording, which applies from 1 July 2005.

Some other subjects in the working environment act are the state of working environment, general obligations, minors, co-operation between employers and employees and penalties.

The Working hours act was established at 1983 and includes the rules of how much you are allowed to work a day, a week and a year and also the amount of breaks you are entitled to. [29] [30]

3.2 The environmental work in Sweden

The Swedish government has decided that Sweden will, until the next generation (year 2010) solve the great environmental problems. This is the goal for the environmental work.

The government has formulated 16 different environmental quality objectives to describe how the environment is supposed to look like. The national board of housing, building and planning has been given responsibility for the environmental quality objective of "Good buildup environment" and the blanket environmental quality objective of Physical planning and house holding of the land, the water and the buildings.

This work is being done in different levels in the country and is coordinated by environmental council (Miljömålsrådet) and its secretariat.

With the environmental quality objectives means that the central authorities transferred more to the players to decide how to achieve the goals, instead of national micro-manage with the laws. However, this requires methodical follow-up.

The environmental quality objectives are reported every year. [27]

3.2.1 The Environmental Code (Miljöbalken)

Environmental Code took effect January 1, 1999 and is a coordinated, broader and more stringent environmental legislation for sustainable development. It collects the laws from 16 different earlier environmental laws. The code has 33 chapters and about 500 sections but only contains the most based environmental rules. To this come a large number of rules and regulations that have been granted under the provisions of the Environmental Code.

> "The purpose of the Environmental Code is to promote sustainable development which will assure a healthy and sound environment for present and future generations." [31]

3.2.2 Environmental Impact Statements (EIS)

Chapter six of the Environmental Code regulates when environmental impact statement (Miljökonsekvensbeskrivning) is required.

Environmental impact statement is required for a detailed plan, if the implementation of the plan is likely to have significant environmental impact. By Swedish legislation is now EIS required in connection with the state of trial, regardless of the environmental impacts.

It is up to the municipality to estimate for every detail plan if it requires an EIS. When it has decided that an environmental impact statement is needed, significant impact must be identified, described and valuated. It should also contain alternatives that are reasonable. The viewpoints from authorities, municipalities and the general public will also be taken in consideration.

3.3 LCA – Life Cycle Assessment

Life Cycle Assessment (LCA) is a method used to look at a material's external environmental impact. The amount of environmental disturbance caused in the form of energy consumption and releases to land, air and water is calculated. In any case, life cycle analysis is a good tool for improving a production process.
It can also be named as Life Cycle Analysis or Eco-balance.

LCA has two main steps that explain what it investigates:

1. Describe which emissions will occur and which raw materials are used during the life of a product. This is usually referred to as the inventory step.

2. Assess what the impacts of these emissions and raw material depletions are. This is referred to as the impact assessment step.

The most common and maybe the most important usage of LCA are in the developing process in the companies. Through that, there is an increasing knowledge about the product and its impact on the environment and it shows what is important in the work of environment. [32]

Today, more and more companies and organizations use LCA for their environmental work. By increased demand for environmental information, stronger environmental legislation in the EU and an increased trend towards globally responsible businesses is the use of LCA spread in the industries and in the society.

The Nordic countries were leading in doing LCA and to develop the method during the 1990s, they were working strong with the development of the international LCA-standards. Since the beginning of year 2000 the rest of the world, first Europe and then Asia, has followed this method with fast development of industrial, commercials and societal appliances.

In Sweden, we already use the LCA in research and in the industries and the LCA also is applied in food production. [32]

3.4 Materials and Waste

3.4.1 Building with Concrete

The most common techniques of building with concrete in Sweden today is with the use of cast in place or to build with pre-fabricated elements. The industry of pre-fabricated elements is highly developed and the elements are used as slabs, staircases and walls. The advantages of the pre-fabricated element is that it is time efficient as the elements are quickly put in place after being finished at the industry.

Studies are made which are showing that a big amount of the consumption of recourses in the building process is a waste. By building industrialized it is possible to reduce a lot of the waste since it is easier to order the needed elements than to count what amount of concrete block that is needed, for example.

A pre-fabricated frame improves the conditions of the working environment at the construction site with less accidents and work-related injuries as a consequence. The construction will also have the benefits of being independent of the weather conditions. [33]

One kind of pre-fabricated elements that can be used is a sandwich element, which is build up of two layers of concrete anchored to each other by pieces of stainless steel. Between the layers of concrete it is a layer of insulation, normally in the material of foam or stone wool. The elements are mostly done in heights of one story and wideness of varying sizes.
From a technical and an economical point of view, this is the element with the most benefits since the wall is completed right away when it is installed, with the surfaces finished from the industry, on both the inside and the outside. [33]

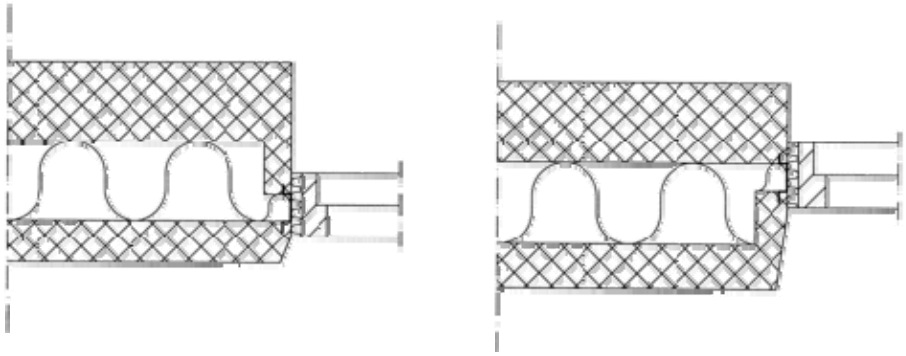

Figure 21 Sandwich element

Environmental problems
One problem with the concrete is that in the future, the collection of natural gravel will be limited to protect the landscape and groundwater. But we have to consider that it requires four times more energy to produce aggregates by the crushing of rock compared to natural aggregates.

Close to the large cities in Sweden there is no natural gravel left because it has been used for asphalt and concrete production.
Asphalt is now produced by crushed rocks, for example quartzite, and fulfils the demand for resource-saving construction
One of the 16 environmental objectives in Sweden is that year 2010 the removal of the natural gravel should not exceed 12 million tons a year. We must replace the natural gravel with crushed rocks. [33]
It is better for the environment to re-use whole concrete blocks than to crush the concrete and use it as filling in new cast concrete.

3.4.2 Waste Management

Laws
The environmental code has the overall legislation about waste and waste management together with regulations, rules and general guidance connected to the environmental code.

Waste management is affected, apart from the laws, even of the basic environmental policy objectives, which are in the national environmental quality objectives, particularly the objectives Non-Toxic Environment and Good Built Environment.

In addition to the Environmental Code, there is also a law on taxes on waste that requires that a tax must be paid for bringing waste into a landfill or store the waste for a longer period than three years. [35]

Since the early 1990s, it has been a societal priority objective in Sweden to increase reuse and recycling of building materials and to reduce the amount of construction and demolition waste going to landfills. The amount of construction and demolition waste going to landfills has decreased from 900 000 tonnes in year 1994 to 530 000 tonnes in year 2002, a reduction with 41%. [34]

3.5 Urban Planning with Environmental Objectives

This is a model, developed and based on projects in Sweden, made for planning a society with the purpose to fulfill the environmental objectives of the country. A project of introducing and adapting this model has been done in South Africa with successful result, which shows that the model is applicable outside Sweden in development countries. The investigation of the model is done to see if it can also be used in the city of Santo Domingo which has similar conditions as the cities of the South African project.

3.5.1 SAMS

Urban Planning with Environmental Objectives in Sweden, SAMS (Samhällsplanering med Miljömål i Sverige),SAMS is a project that the National Board of Housing, Building and Planning have been working on together with the Swedish Environmental Protection Agency in cooperation with municipalities and county administrative boards.

The purpose of the project has been to develop and strengthen the municipalise work of planning so that environmental aspects could better be integrated into the physical planning.

One of the basic ideas has been to have a close involvement between environmental experts and planners from the start until the end of a project of urban planning. Environmental issues are now discussed early in the process of planning. [36]

Two studies have been done in South Africa that shows that these Swedish methods are adjustable and applicable in other countries.

The final report of the studies in South Africa was received from the National Board of Housing, Building and Planning. By the report it is possible to see how they were working with the project and if the Swedish model also can be applicable in the Dominican Republic.

The final report of Environmental Objectives and Indicators in Spatial Planning and SEA, Kimberley and Port Elizabeth South Africa, tells about the most important issues that is the reason for the project of SAMS.
The following text is a resume of the final report.

"Knowledge of environmental matters is often strictly sectorial. There is little overlapping between different areas and the knowledge that exists, although it is often profound and extensive, is not well adapted to planning purposes. A translation and overlapping mechanism needs to be developed in order to make it possible to use this knowledge in the planning process."

"Methods need to be developed for the integration of environmental aspects into spatial planning."

"Large amounts of environmental data need to be processed and visualized in such a way as to be available for planning purposes."

"The importance of spatial planning as a factor contributing to sustainable development is not sufficiently understood and needs to be clarified."

Environmental objectives are often widely formulated and hard to interpret in how to use them in the spatial planning and in the building sector. It must be created ways to adapt the environmental objectives for the purpose of the building sector and the spatial planning. To achieve the concept of objective-oriented planning it must be ensured that it is accepted by politicians and the public.
"The criteria for a environmental objective are that they should be measurable, tied to a time limit, easy to understand for a layman."

SEA –Strategic Environmental Assessment
SEA is a method to measure and evaluate the Sustainable Development; the potential environmental, social, and economic impacts of Policies, Programs and Plans. "It works on a strategic level. The idea is to get a basis for holistic decision-making. SEA is a pro-active tool." The use of CUP and indicators (see the following text) is valuated and referred to objectives by SEA.

CUP- Comprehensive Urban Plan
Is a strategic land-use plan. It shall tell how the plan will impact the Social, Environmental and Economic situation of the city. It shall be a public process where a various group of people participates and are involved in investigate how the plan will impact the S,E,E-situation.

The CUP is going to have some over-all goals, which also needs to be translated to more specified objectives. It is important to control how the environmental objectives of the CUP are achieved and finding out in what way spatial development can support the achievement of the objective. This is being done by using different indicators.

The South Africa project aims to establish what needs to be done in the context of spatial planning. To control how the environmental objectives are achieved in the concept of Comprehensive Urban Planning, indicators was used. In the project they used two different kinds of indicators, Field indicators and Planning indicators.

Field indicators are linked to environmental objectives and can also tell about trends. They can be used to compare a plan's intentions to the real developments. Politicians and public can be informed and learned about environmental trends in relation to environmental objectives by the information of the field.

Planning indicators are not based on actual environmental conditions. They shall be used to demonstrate the impact that a plan or a planning alternative would have on the environment, and the environmental objectives, if it was implemented.

"The main overall purpose of the project is to develop methods of integrating environmental aspects into spatial planning and demonstrating and developing the potential of the plans for achieving these objectives. The method is based on the development of environmental objectives and indicators that are relevant for planning."

To develop sustainability indicators a method called PICABUE, developed at the Environment Center, University of Leeds, is being used. The purpose is to develop objective-related indicators to measure a city's way towards sustainability. The bases for the methods are the four principles identified at the Rio conference 1992; the future, Democracy, Environment, Equity. There are seven steps to develop the indicators that comply with these four principles;

The seven steps of PICABUE
- Stakeholders to consensus on principles of sustainable development and objectives of indicator use.
- Identify and select issues of concern.
- Construct/select base indicators of quality of life issues of concern.
- Augment quality of life indicators with reference to sustainability principles to produce sustainability indicators.
- Modify sustainability indicators to account for boundary difficulties.
- Supplement sustainability indicators with uncertainty indicators.
- Evaluate final sustainability indicators with respect to desired indicator characteristics and objectives of indicator programme.

The method gives a large chance that it will become hundreds of indicators. To reduce them a summary of all the indicators is send out to all the participants to value them from its relevance to the objectives. All the inhabitants of the municipality receive a brochure on the objectives and the indicators and are asked to choose three indicators on every issue. When the most relevant indicators this way are chosen a search for data to measure the indicators starts.

"The PICABUE-method has been used with success by the Stockholm municipality as a part of their Local Agenda 21 work"

"The indicators a society chooses to report itself are surprisingly powerful. They reflect collective values and inform collective decisions. A nation that keeps a watchful eye on its salmon runs or the safety of its streets makes different choices than does a nation that is only paying attention to its GDP" [38]

The proposed indicators for the project in Kimberly, South Africa are all field-indicators developed in the issues of waste, energy, water, open space and conservation. The indicators are measurable in the following way;

Waste –change in amount of waste dumped at the municipality dumpsite.
Energy –change in number of installed units of solar heaters, wind power, bio gas.
Water –change in volume of intake of potable water.
Open space –area of parks developed.
Conservation –changes in number of units and areas identified for conservation considerations.

A separation of the indicators in economic, social and environmental categories was done in Kimberly. In hindsight of this it's understood that this might not always be the best solution as the indicators sometimes are closely linked to each other. One of the thoughts was that it maybe would be better to put them all under the label of indicators for sustainable development.

A evaluation of the South Africa project gives the conclusion that "almost everyone is convinced that public participation has to increase to attain sustainable development; not only to make agreements on what there is to be done but also to make people aware of their own responsibility for the development."

"When it comes to environmental objectives and indicators everyone is convinced that indicators from an important instrument to show weather the progress is on the right track or not, and to inform people of the development"

"A great effort has been put into involving the citizens of Kimberly in the planning process. Meetings on various issues have been arranged both in neighbourhoods and other fora. The public has displayed great interest."

"Interviews were held with people who are involved in the planning process about their opinions on the CUP process… The main conclusion from these interviews is that almost everyone agrees about the work on the CUP being successful in the aspect of integrating environmental issues and Agenda 21 into the planning process and also in making people that were involved aware of the importance of environmental development."

"A very important issue when working with the concept sustainable development, discovered in both pilot projects and CUP-work, is *environmental awareness.* To help/educate people by public participation to be aware of their consequences of their own actions as well as to understand different actions from the municipality is a very important task." [39]

4 What is Applicable in the Dominican Republic?

This chapter is a discussion of models and techniques that are currently used in Sweden and which could mean a development of the building sector and the society by being introduced in the Dominican Republic. The discussions are based on the information presented in the chapters of The Dominican Republic and Building in Sweden.

4.1 SAMS

After the studies of the model of SAMS and the way the Dominican government are working with the urban planning and the environmental management at the moment and the reports on the procedures of the project we think that the model is fully applicable also in the Dominican Republic. The following discussion will consider parts that is already a good base for introducing SAMS in Santo Domingo and parts that need to be developed and concretized for working according to the model.
The most important thing to start with is that environmental objectives need to be created. The objectives need to be very clear and easy to understand. They should also be measurable and tied to a time limit. Looking at the Dominican Republic, they have a national program to work with Agenda 21 and also a mission and a vision for the environment. This is a good start for working with SAMS, though the statements are very widely formulated and needs to be more concrete. The building sector needs to be given and embrace some of the environmental objectives that they need to achieve. For example, the objectives that are given the Swedish building sector. The overall objective needs to be taken down into city-level so it is applicable in a city like Santo Domingo and used in the question of how to achieve the object by spatial planning.

Working with SAMS means to work with urban planning with environmental objectives. Urban planners and environmental investigators need to work together already in the early planning process to adapt plans that helps to achieve the environmental objectives, to create a sustainable society. One of the problems of how the planning works today is that the planning department DGPU and the department of Environmental Management are working separate from each other. This need to be changed to use the benefits from each other's knowledge for a sustainable society.

The government of the Dominican Republic has found that national environmental indicators need to be developed and they have been looking for a method adjusted to choose these indicators. This shows that they are standing open for the method. Our suggestion is that they start by choosing relevant environmental objectives and then use the PICABUE-method in how to choose the proper indicators by involve the citizens of Santo Domingo. Just as reported from the project of Kimberly, South Africa, we think that "public participation has to increase to attain sustainable development; not only to make agreements on what there is to be done but also to make people aware of their own responsibility for the development." [39] To increase the people's knowledge and interest of the environment is desired by the government in their National Strategy of Environmental Education. It is a good approach, for a development in the awareness of the environment and a sustainable Santo Domingo and we hope that it will be fulfilled, not only on the papers. The environment and the

sustainability will also need to be included in courses of high level of education in different kinds. For example one of the experiences from the Minor Field Study was that the students of civil engineering are not having any courses in this. From our opinion we think that courses in for example building and the environment would be necessary to make future engineers aware of the participation in all sectors is a must for creating a sustainable society. We believe that knowledge increases the interest of participation, and by learning more about how people can affect the environment, they are also willing to participate in choosing relevant indicators.

This is a proposal in how to work on environmental objectives and indicators through the table developed in the preliminary study of the SAMS-project. We think that this example from Kimberly [39] also can be applied in Santo Domingo.

Objective adopted to spatial planning	**Planning indicator or Field indicator**	**Planning actions**	**Other actions**	**Responsibility (Dpt, section...)**
Create necessary conditions for developing public transports (PT)	Planning indicator: Roads that can be used for PT/roads demanded Field indicator: change in no. persons on PT Roads developed for PT	Restoration of roads good for PT, bus stops, signs.	Information, cooperation with PT sector Busses with bio-fuel.	City Engineers Public transportation sector
Objective adopted to spatial planning	**Planning indicator or Field indicator**	**Planning actions**	**Other actions**	**Responsibility (Dpt, section..)**
Create possibility for pedestrians and bicyclist by well-thought connected pedestrian and bicycle lanes.	Planning indicator: No persons with x distance to good pedestrian and bicycle lanes Field indicator: No persons walking or cycling/original situation.	Develop safe and well thought connected p/b lanes	Information campaign on possibilities to walk and bicycle, environment and health	City Engineers Health dpt.
Objective adopted to spatial planning	**Planning indicator or Field indicator**	**Planning actions**	**Other actions**	**Responsibility (Dpt, section..)**
Create car traffic free zones	Planning indicator: areas of car closed shopping streets, with meeting places and green structure Field indicator: Change in air pollution in the original situation	Close shopping streets for car traffic Create space for outside cafes and restaurants Tree planting and benches	Co-operate with stakeholders in the area Public information on the environment	City Engineers Park and recreation section

Figure 22 Example of how to create cleaner air

4.2 Concrete

Maybe it could be a possibility to use more prefabricated concrete instead of all the concrete blocks. Prefabricated concrete elements have many advantages for example it is time effective, lowers the amount of labor and thereby also the building cost.

Sandwich element for the outer wall is an alternative that makes the building lighter and it also have many other advantages. This sort of element is stable and the insulation prevents the heat from the sun to be stored and spread through the wall to the inside of the house in the same amount as the concrete blocks. With the warm climate that exists in the Dominican Republic it is important from the energy consumption point of view to keep the warmth outside to keep the use of air condition down.

The construction of sandwich element is also less heavy than the blocks that are currently used for the walls. From the field studies it was seen how they are using pieces of foam in the concrete, covered by a thin layer of fine cement with the attempt of making the construction less heavy. The construction gets less heavy, but problems remains with for example cracks in the sealing and with fire security; if the layer of covering concrete is to thin and the foam gets heated and starts to drop in the case of a fire. The use of element could be a solution to these problems. The current technique for a less heavy building was relatively new at the constructions, though they are familiar with working with foam and concrete which gives a potential of developing the technique into working with sandwich elements.

They are trying to build more and more with prefabricated concrete, but so far, it is too expensive. The industry do exist but in a very small scale and they are all new to this technique. Education is necessary for the procedure of developing the industry.

4.3 Sun Energy

In a country like the Dominican Republic with so many hours of sun, it should be very useful, economical and environmental friendly to use the energy from the sun. It is not common to see solar collectors on the roofs in Santo Domingo, people think that it is unnecessary and says that the solar collector will be stolen.

Many of the houses in Santo Domingo do not have any hot water supply and that means no energy consumption. Maybe it is just a question about living standards. Some houses are using water tanks for the hot water supply. The tanks are placed on the roof where they are exposed to the sun. The sun-heated tanks provide the apartments with hot water. This method is widespread but can be applied more often, many houses have these tanks but only few of them are in use. A problem with the tanks is that the hot water runs out comparing to heat the water with gas or electricity where there is hot water all the time.

4.4 LCA

By involving LCA in the developing process of the building sector and look at the materials and the methods environmental impact, there is a possibility to lower the environmental disturbance. Even if it is not possible to apply the whole LCA-method, it might make a difference just to add the thoughts of the environmental affects. In the building sector, this way of thinking could be applied in the planning of the buildings. Some problems with LCA are that it is still in a developing progress, it is very expensive to do a LCA and it is hard to define what environmental problem that is the worst. Another problem is that important pieces as the electricity production, reuse and garbage incineration vary significantly between different countries and makes it hard to compare to each other.

More problems with life cycle analysis are that it takes a lot of time, and that the result can be influenced more by the production technique than the qualities of the material itself.

LCA is not a fully developed method. It will never be the basis for a continuous control but it is a very good tool to demonstrate the limitations and define problems while searching for improvements.

4.5 Working Environment

There must be regulations on the construction site to prevent accidents. The motion could be regulations about protection against falling, stable rails with enough height, building helmets and safe building elevators.

There should be one responsible person who has the coordination responsibility and is in charge of the security at the construction site. This person should have steady controls to check that the regulations are followed. Otherwise this should be executed immediately and followed with penalties.

The regulations about work condition must be taken seriously and must concern all the workers no matter what citizenship, ethnicity, gender or age. This is the first and most important step towards a sustainable society with ecological, economical and social aspects.

If all the workers are given the same condition and payment for the work, they will realize that the way they are building today is not sustainable for the future.
The new methods must be developed and established in the country to make it easy to change the building with concrete blocks to a more efficient and cheaper method.
By receiving help from other countries that is already using the new method, they can see that it actually works and they don’t have to repeat the mistakes that the industrial countries had to pass in the progress of developing these new techniques.

4.6 Waste

The reuse and recycling of building products can be the easiest and most efficient change for the environment in the Dominican Republic, especially the recycle of concrete.

The waste management is a large problem and needs to be taken care of. Emissions from burning waste harm the environment and there is no sustainable solution to dump the waste in the rivers. More organized dump yards needs to develop who can take care of the garbage in a good way and also recycle as much as possible.

In the Dominican Republic, they are burning a lot of the waste, wood, paper and plastic. This is just a way to get rid of the waste and they do not take advantage of the energy or take care of the hazardous emissions from the burning plastic.

4.6.1 Reuse of Building Materials

In order to take advantage of as much energy as possible it is important to recycle and re-use the building materials.

With the right equipment, the preparation that is required and enough time to dismantling, many building products from demolition can be re-used without changing the function, for example, windows, insulation, roofing, doors and cabinets. Sometimes there are new requirements to take in consideration, for example safety, thermal insulation or similar.

The Dominican Republic has some reuse in their building process. They use the wooden casting molds several times, the wooden scaffolds are being used up to four times and some of the concrete blocks are being reused.

It is better for the environment to re-use whole concrete blocks than to crush the concrete and use it as filling in new cast concrete.

4.6.2 Recycle

There can be much more recycling in the building sector than it is today in the Dominican Republic. A company in Sweden claims that they can recycle or burn, and take advantage of the energy, up to 95% of the building waste. That means that only 5% goes to landfills. [40]

There is no reuse or recycling at all of the concrete from the houses which are demolished. This is a huge loss of energy that could save a lot of the energy and also reduce consumption of natural gravel.

There is a possibility to recycle all concrete.
Some of the old concrete can be recycled as aggregate in new concrete or as well as crushed concrete for road construction or similar purposes. There are also examples

when recycled concrete elements, which after dismantling come to use in new housing or industrial premises. The goal in Sweden is that no concrete products have to go to landfills or, conversely, 100 percent will be able to reuse in new buildings or recycled crushed concrete.

The national board of housing, building and planning has been commissioned by the Swedish Government to present a progress description of the waste management in the building- and construction sector. [41]

5 Final Words

The Dominican Republic and Santo Domingo has already started to work towards a sustainable and ecological society, but still, there is a long way to go.

The Dominicans have simple-track thinking about their own construction and it has been difficult for us to make discussions about new proposals for example with building materials. Most often we were given the reason that they just need to build as cheap as possible and the mind is sat on that the way of doing that is to keep on building like it always has been done. We found that many people in Santo Domingo would like to have a more comfortable climate in their residences. Today this is created by using money and energy squandering air conditions; we think that the problem instead could be build away by developing the building technique, which could be a money saver in the end.

The tradition of cheap illegal labor from Haiti without focus of human rights has been hard to discuss, since everyone knows that it is unfair but think that the conditions don't need to be changed because of the free will of the Haitians to work under those conditions. Public discussions of human rights need to be brought up and put in focus by media and government.

The work towards a sustainable city has to continue at all levels in the society to involve all the people and to achieve success.

Problems that we have had during our work with the thesis in the Dominican Republic have been a small lack of proper literature. This is connected with incidents that made the thesis take another direction than we had planned and packed for, leaving from Sweden.

The language has also been a source of problem since none of us were speaking proper Spanish and the English knowledge of many Dominicans we met were a lack, this could be a source of misunderstandings that might occurred. Most of the governmental documents of information were in Spanish which made it complicated, but we got a great help with the translations though.

The time we spent in the country were relatively short to get a completely and fair look at the whole building sector. It would have been interesting if we have had the time to make a presentation and a discussion of our suggestions in place in the Dominican Republic.

We think that the purposes of our thesis have been achieved. We have got a interesting sight of the building procedure of the country and found a couple of models and techniques that we are working with in the country of Sweden today that we also think could be adapted in the Dominican Republic for a development of a sustainable society and the building sector. Our main suggestions from the discussion in the previous chapter are summarized below:

Our suggestions of main improvements are:

To work according to the model of SAMS, that is to work to achieve the environmental objectives through a well-reasoned urban planning where planners and environmental investigators work together in the planning process.

To save energy and reduce the loss of natural gravel by starting to re-use and recycle the massive amount of concrete that is being used in the building sector. Recycling need to be introduced in the waste management in the rest of the community as well.

To install solar collectors to provide hot water to the buildings and by that reduce the amount of gas and electricity.

To use more prefabricated concrete elements like sandwich element with all the benefits that comes by the new technique.

To involve LCA in the building sector and inform about the consequences of thinking ecological.

To continue the education of people's awareness of the environment.

The environmental problems of a country are not just an issue of the specific country, but a problem that affects the whole world, since we are sharing the same earth. By sharing our knowledge and make suggestions in how to spare the earth by working with the ecological and sustainable methods country to country, we are also helping ourselves for a brighter future.

The building sector is today responsible for using a great part of the recourses of the world. If we can reduce that and plan and build in a more ecological and sustainable way we have come a long way.

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Pictures

Figure 1 Maps,
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Figure 2 Unsafe scaffolds
Private picture

Figure 3-5 Statistics over different houses in the Dominican Republic
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Figure 6 Apartment plan
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Figure 7 Tejamanil,
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Figure 8 Statistics over materials in walls
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Figure 9 Statistics over material in roofs
www.one.gob.do

Figure 10 Statistics over material in floors
www.one.gob.do

Figure 11 Solar collectors
Private picture

Figure 12 An area to collect waste from the construction site
Private picture

Figure 13 Concrete block wall
Private picture

Figure 14 Scaffolds
Private picture

Figure 15 Building Crane
Private picture

Figure 16 Facade Torre Shalom II
Private picture

Figure 17 Construction site, lower parking deck
Private picture

Figure 18 Slab with foam
Private picture

Figure 19 Home for the Haitian workers
Private picture

Figure 20 Sheds in the slum area
Private picture

Figure 21 Sandwich element
www.betongvaruindustrin.se Bygga med prefab

Figure 22 Example of how to create cleaner air
The final report of Evironmental Objectives and Indicators in Spatial planning and SEA, Kimberley and Port Elizabeth South Africa.
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