Jimma University

School of Graduate Studies

Jimma Institute of Technology

Department of Civil Engineering

Construction Engineering and Management stream

Case Study on The Use of Sustainable Building Materials

A case study submitted to the school of graduate studies of Jimma University

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DECLARATION

This case study is my original work and has not been presented for a degree in any other university.

Submitted by	Signature	Date

This case study has been submitted for examination with my approval as university supervisor.

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ABSTRACT

Sustainability has acquired great importance due to the negative impact of various developments on the environment. The rapid growth during the last decade has been accompanied by active construction, which in some instances neglected the impact on the environment and human activities. Within the last decade sustainable development and building practices have acquired great importance due to the negative impact of various development projects on the environment. In line with a sustainable development approach, it is critical for practitioners to create a healthy, sustainable built environment.

With significant growth taking place in the building sector, the burden being placed on limited resources is increasing – resources that one day will run out. What's more, ongoing fit outs, extensions and / or refurbishments increase the environmental impact during a building's life cycle. Many natural resources and building materials require mining, processing, refining and ultimately manufacturing, transport and delivery before they are utilized in construction. The energy used during these processes is commonly known as embodied energy.

Therefore to decrease this environmental degradation architects and engineers should become more knowledgeable about the materials they use and should involve in the material selection process. This case study focused on the characteristics and features of sustainable building materials in selection of sustainable building materials.

KEY WORDS: EMBODIED ENERGY, ENVIRONMENT, LIFE CYCLE, RESOURCES, SUSTAINABLE BUILDING MATERIALS

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CHAPTER ONE INTRODUCTION

1.1 BACKGROUND

The main objectives of sustainable construction activities are to avoid resource depletion of energy, water, and raw materials and to prevent environmental degradation caused by facilities and infrastructure throughout their life cycle.

In the modern world, architecture has a greater focus on preserving the environment and its resources. Knowing that most of the non-renewable energy sources are running out makes us think of new ways to lower the energy and raw material consumptions. The most common thing that architects and engineers are trying to improve is the energy consumption of the building after it is built. The energy consumed in the process of building a house takes huge amounts of recourses therefore through a Life Cycle Assessment we can find a solution to our problem and the most suitable materials for a certain building.

Careful selection of environmentally sustainable building materials is the easiest way to incorporating sustainable design principles in buildings. Traditionally, price has been the foremost consideration when comparing similar materials or materials designated for the same function. However, the “off-the-shelf” price of a building component represents only the manufacturing and transportation costs, not social or environmental costs.

A “cradle-to-grave” analysis of building products, from the gathering of raw materials to their ultimate disposal, provides a better understanding of the long-term costs of materials. These costs are paid not only by the client, but also by the owner, the occupants, and the environment. The principles of Life Cycle Design provide important guidelines for the selection of building materials. Each step of the manufacturing process, from gathering raw materials, manufacturing, distribution, and installation, to ultimate reuse or disposal, is examined for its environmental impact. A material’s life cycle can be organized into three phases: Pre-Building; Building; and Post-Building. These stages parallel the life cycle phases of the building itself.

1.2 STATEMENT OF THE PROBLEM

Sustainable building materials by definition are materials that are locally produced and sourced (which reduces transportation costs and CO2 emissions), they can include recycled materials, they have a lower environmental impact, they are thermally efficient, they require less energy than more modern, conventional materials, they make use of renewable resources, they are lower in toxic emissions and they are financially viable.

Sustainable building materials should be utilized appropriately and contextually in each neighborhood development. The use of sustainable building materials not only reduces transport costs, carbon emissions, and in most cases materials costs, it also provides employment and skills development opportunities for community members.

Nowadays investigations show very pessimistic results. Scientists state that the earth's resources on certain building materials and raw materials are running low. We should be very careful in how we as responsible human beings use the vanishing material. Therefore, in order to preserve the raw material resources of building materials, we have to think of new and more durable solutions to the given problem.

1.3 RESEARCH QUESTIONS / HYPOTHESIS

1. What are the tools for the assessment of environmental sustainability of construction products?
2. What are the features and selection criteria of sustainable building materials?
3. How do we prevent environmental degradation caused by the building materials throughout their life cycle?

1.4 OBJECTIVE OF THE STUDY

General objective

- To understand the concept of sustainable building materials.

Specific objective

- To give tools for the assessment of environmental sustainability of construction products
- To identify the features and selection criteria of sustainable building materials
- To prevent environmental degradation caused by the building materials throughout their life cycle

1.5 JUSTIFICATION/RATIONALIZATION

Within the last decade sustainable development and building practices have acquired great importance due to the negative impact of various development projects on the environment. In line with a sustainable development approach, it is critical for practitioners to create a healthy, sustainable built environment. In Europe, 50% of material resources taken from nature are building-related, over 50% of national waste production comes from the building sector, and also 40% of energy consumption is building-related. More attention should be directed towards establishing sustainable guidelines for practitioners.

Sustainability has been defined as the extent to which progress and development should meet the need of the present without compromising the ability of the future generations to meet their own needs. This encompasses a variety of levels and scales ranging from economic development, and agriculture, to the management of human settlements and building practices.

1.6 SCOPE OF THE STUDY

The scope of this case study is to identify whether or not a building material is a sustainable building material. And it also helps in categorizing a building material according to its features.

1.7 MOTIVATION OF THE STUDY

The main motivation that drives me to work on such a very broad topic is my interest to explore sustainable construction activities by avoiding resource depletion of energy, water, and raw materials and to prevent environmental degradation caused by facilities and infrastructure throughout their life cycle.

1.8 SIGNIFICANCE OF THE STUDY

The findings of this study provide practitioners and academics with a clear understanding of the use sustainable building materials for further studies on the concept and in selection of sustainable building materials for construction projects.

CHAPTER TWO LITERATURE REVIEW

3.1 INTRODUCTION

Sustainable building materials can be defined as materials with overall superior performance interims of specified criteria. The following criteria are commonly used:

- Locally produced and sourced materials
- Transport costs and environmental impact
- Thermal efficiency
- Occupant needs and health considerations
- Financial viability
- Recyclability of building materials and the demolished building
- Waste and pollution generated in the manufacturing process
- Energy required in the manufacturing process
- Use of renewable resources
- Toxic emissions generated by the product
- Maintenance costs. “Pierre Roux and Alex Alexander, 2007”

A building inevitably consumes materials and energy resources, the technology is available to use methods and materials that reduce a building's environmental impacts, increase operating efficiency, and increase durability. “University of Nottingham, 2003”

As the resources of raw energy and building materials are running low, we have to find new solutions to the problem. The reduction of the building industry’s energy consumption is of great importance and low embodied energy is the key to a great success in solving that issue. “Lazar Petrov Petrov, 2011”

The main objectives of sustainable construction activities are to avoid resource depletion of energy, water, and raw materials and to prevent environmental degradation caused by facilities and infrastructure throughout their life cycle.

The methodology for assessing the environmental impacts of a product or service over the entire life cycle is called Life cycle assessment. A life-cycle assessment is defined as "(also known as life-cycle analysis, eco balance, and cradle-to-grave analysis) a technique to assess environmental impacts associated with all the stages of a product's life from-cradle-to-grave (i.e., from raw material extraction through materials processing, manufacture, distribution, use, repair and maintenance, and disposal or recycling)."www.wikipedia.org October 2011"

In the modern world, architecture has a greater focus on preserving the environment and its resources. Knowing that most of the non-renewable energy sources are running out makes us think of new solutions and ways to lower the energy and raw material consumptions. The most common thing that architects and engineers are trying to improve is the energy consumption of the building after it is built. The energy consumed in the process of building a house takes huge amounts of recourses therefore through a Life Cycle Assessment we can find a solution to our problem and the most suitable materials for a certain building.

Applying life cycle assessment within the construction sector is an important tool for achieving sustainable development and design. By integrating the information on emissions of dangerous substances life cycle assessment enables the impact assessment of relevant materials in different use, recycling and disposal options. Indicators used in life cycle assessment for the environmental impacts related to the release of dangerous substances are usually eco-toxicity and human toxicity. Life cycle assessment can also be used to assess the overall impacts related to recycling of waste or secondary material in order to save natural resources, including both environmental benefits and load related to the recycling process. Every life cycle assessment is structured in four different phases:

- Goal and scope
- Life Cycle inventory
- Life cycle impact assessment
- Interpretation (See figure 1)

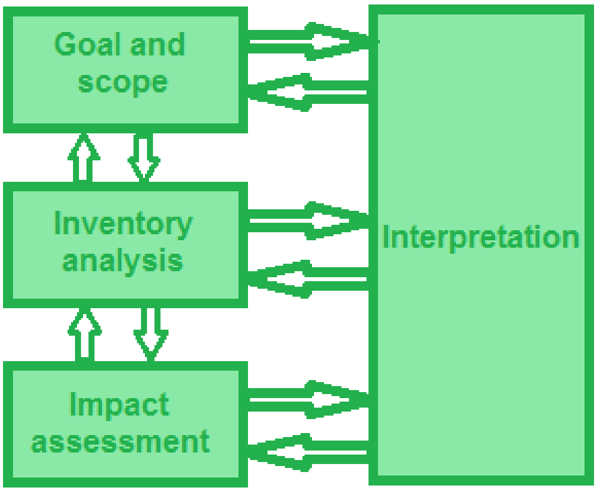

Figure 1 showing the main flow of the life cycle assessment

The "Goal and scope" phase of the study is basically the beginning of the life cycle assessment, where one should state in what method and to whom the results should be given. The "Goal and scope" document is used as a guide to give us the readers' further information on:

- The function unit
- The boundaries of the system
- Assumptions and limitations.
- The allocation methods used to separate the environmental load of a process when different products and functions are used in the same process.
- The impact categories chosen.

The Life Cycle Inventory and its main function are creating an inventory flow of products from and to nature for a certain product system. The flows usually include inputs of water, energy, raw materials and outputs to air, land and water.
The Life cycle impact assessment follows the inventory analysis. This past of the life cycle assessment is where we evaluate the potential environmental impact of the process and products based on the flow model.

- The categories of impact have to be selected
- The classification stage
- The impact measurement

The life cycle interpretation is where we systematically identify, quantify, check and evaluate the information from the results of the life cycle inventory and/or impact assessment. Here we also summarize the results of the previous phases. The basic idea of the interpretation is to provide conclusions and recommendations for the given study.

The principles of Life Cycle assessment provide important guidelines for the selection of building materials. Each step of the manufacturing process, from gathering raw materials, manufacturing, distribution, and installation, to ultimate reuse or disposal, is examined for its environmental impact.

We can also categorize the life cycle of a product into three life-cycle phases pre-building phase, building phase and post-building phase. This three life cycle phases relate to the flow of materials through the life of the building (see Figure 2).

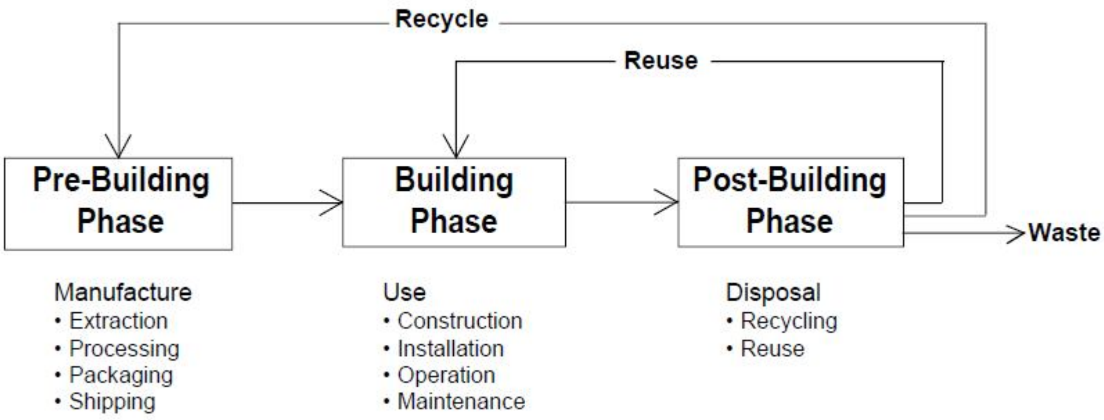

Figure 2 Three phases of the building material life cycle

The Pre-Building Phase describes the production and delivery process of a material up to, but not including, the point of installation. This includes discovering raw materials in nature as well as extracting, manufacturing, packaging, and transportation to a building site. This phase has the most potential for causing environmental damage. Understanding the environmental impacts in the pre-building phase will lead to the wise selection of building materials. Raw material procurement methods, the manufacturing process itself, and the distance from the manufacturing location to the building site all have environmental consequences. An awareness of the origins of building materials is crucial to an understanding of their collective environmental impact when expressed in the form of a building.

The Building Phase refers to a building material's useful life. This phase begins at the point of the material's assembly into a structure, includes the maintenance and repair of the material, and extends throughout the life of the material within or as part of the building.

The Post-Building Phase refers to the building materials when their usefulness in a building has expired. At this point, a material may be reused in its entirety, have its components recycled back into other products, or be discarded.

3.2 FEATURES OF SUSTAINABLE BUILDING MATERIALS

The presence of one or more of these features in building materials make it environmentally sustainable.

3.2.1 Pollution Prevention Measures in Manufacturing

Environmental sustainability can be controlled significantly by pollution prevention measures taken during the manufacturing process. Identical building materials may be produced by several manufacturers using various processes. Some manufacturers are more conscientious than others about where their raw materials come from and how they are gathered. In effect, they perform their own life cycle analysis of their processes. Analyzing and selecting products by environmentally responsible companies encourages the pollution prevention measures. Although these products may have an initially higher price in purchasing, choosing products that generate higher levels of pollution exploits the environment.

In many manufacturing processes water is used in large quantities, especially in the production of paper, cement, and metals. This wastewater is often released directly into streams and can contain toxic substances. Even the packaging that is environmentally sound can be pollution prevention feature, as how it is packed and shipped affects the total amount of waste it generates.

Therefore resulting in reduction of demand for the products with higher pollution in other words "law of supply and demand" also works in reverse: reduced demand for a product results in lower production. Lowered production means less waste discharged and less energy consumed during manufacturing, as well as a lower volume of raw materials that must be gathered. By becoming aware of which manufacturers use environmentally sustainable manufacturing methods, specifying their products, and avoiding goods produced through highly polluting methods, we can encourage the marketing of sustainable building materials.

3.2.2 Waste Reduction Measures in Manufacturing

This feature indicates that by reducing the amount of scrap material that results the manufacturer has taken in to consideration to make the production process more efficient. This scrap may come from the various molding, trimming, and finishing processes, or from defective and damaged products. Products with this feature may incorporate scrap materials. Some industries can power their operations by using waste products generated on-site or by other industries. These options reduce the waste that goes into landfills. Oriented strand board and other wood composite materials are made almost entirely from the waste produced during the process of milling trees into dimensional lumber. Kilns used to dry wood can be powered by burning sawdust generated on-site, reducing both the waste that leaves the mill (to be disposed of in landfills) and the need for refined fossil fuels. Concrete can incorporate fly ash from smelting operations. Brick, once fired, is inert, not reacting with the environment. The firing process can be used to encapsulate low-level toxic waste into the brick, reducing the dangers of landfill disposal. Water used for cooling equipment or mixing can be filtered and reused rather than discharged into the waste stream.

Therefore by reducing waste in the manufacturing process we increase the resource efficiency of building materials and reduce the environmental polluting factors.

2.2.3 Recycled Content

A product with this featuring has contents of produced from post-industrial or post-consumer waste. By recycling materials, the embodied energy they contain is preserved. The energy used in the recycling process for most materials is far less than the energy used in the original manufacturing. Key building materials that have potential for recycling include glass, plastics, metals, concrete or brick, and wood. The manufacturing process for all of these materials can easily incorporate waste products. Glass, plastics, and metal can be reformed through heat. Concrete or brick can be ground up and used as aggregate in new masonry. Lumber can be resawed for use as dimensional lumber, or chipped for use in composite materials such as strand board.

Therefore this incorporation of waste materials into usable building products reduces the waste stream and the demand on virgin natural resources.

2.2.4 Embodied Energy Reduction

Preserving the environment could be done in many ways but by reduction of embodied energy of building materials is a great solution to the global problem. The embodied energy of a material refers to the total energy required to produce that material, including the collection of raw materials (see table 1). This includes the energy of the fuel used to power the harvesting or mining equipment, the processing equipment, and the transportation devices that move raw material to a processing facility. This energy typically comes from the burning of fuels, which are a limited, non-renewable resource. The combustion of fossil fuels also has severe environmental consequences, from localized pollution to acid rain. The greater a material's embodied energy, the greater the amount of energy required to produce it, implying more severe ecological consequences. By revisiting the manufacturing process that saves energy will reduce the embodied energy of the material. Conventional materials with a high embodied energy can often be replaced by a material with low embodied energy, while using conventional design and construction techniques.

Table 1Table comparing embodied energy content of common building materials from primary vs. secondary sources.

Material	Virgin	Recycled
Aluminum	196	27
Polyethylene	98	56
Pvc	65	29
Steel	40	18

These figures are for mega joules per kilogram "J. L. Sullivan and J. Hu, 1995"

Therefore the amounts of energy used to produce new materials, to transport them and put them on the site, could rapidly be reduced. And a reduction of CO_2 ignitions could be reached as well.

2.2.5 Use of Natural Materials

Natural materials require less processing and are less damaging to the environment. Natural materials are generally lower in embodied energy and toxicity than man-made materials. Many, like wood, are theoretically renewable.

Therefore when natural materials are incorporated into building products, the products become more sustainable.

2.2.6 Reduction of Construction Waste

Less construction waste during installation reduces the need for landfill space and also provides cost savings. For example concrete mixed on-site as needed, eliminates waste, and offers better quality control than Concrete pre-mixed with water and delivered to the site. Designing floor intervals to coincide with the standard lengths of lumber or steel framing members also reduces waste. Taking advantage of the standard sizes of building materials in the design phase reduces waste produced by trimming materials to fit, as well as the labor cost for installation.

Therefore reduction of construction waste provides cost saving and environmental sustainability.

2.2.7 Local Materials

Local materials are better suited to climatic conditions, and these purchases support local economies. It is not always possible to use locally available materials, but if materials must be imported they should be used selectively and as small in volume as possible. For instance, steel when required for structural strength and durability, is a justifiable use of a material that is manufactured some distance from the building site.

Therefore the use of locally produced building materials shortens transport distances, thus reducing embodied energy.

2.2.8 Energy Efficiency

The ultimate goal in using energy-efficient materials is to reduce the amount of generated energy that must be brought to a building site. The long-term energy costs of operating a building are heavily dependent on the materials used in its construction. Preferred materials slow the transfer of heat through a building's skin, reducing the need for heating or cooling. Quantitative measurements of a building material's efficiency are available to help in the comparison of building materials and determining appropriateness for certain installations.

Therefore Energy efficiency is an important feature in making a building material environmentally sustainable.

2.2.9 Water Treatment/Conservation

Building materials with the water treatment/conservation feature either increase the quality of water or reduce the amount of water used on a site. All water that comes into or leaves a building must be treated. Generally, the water treatment/conservation involves reducing the amount of water that must be treated by municipal septic systems, with the accompanying chemical and energy costs. This can be accomplished in two ways: by physically restricting the amount of water that can pass through a fixture (showerhead, faucet, and toilet) or by recycling water that has already entered the site. For instance, gray water from cooking or hand washing may be channeled to flush toilets; captured rainwater may be used for irrigation.

Therefore Water treatment/conservation issues address efficient use of water as well as an overall reduction in the volume consumed.

2.2.10 Use of Non-Toxic or Less-Toxic Materials

Building materials with non- or less-toxic materials are less hazardous to construction workers and also building's occupants. Many materials adversely affect indoor air quality and expose occupants to health hazards. Some building materials, such as adhesives, emit dangerous fumes for only a short time during and after installation; others can contribute to air quality problems throughout a building's life.

Therefore by selecting materials with non- or less-toxic levels of the toxic materials, environmental health problems can be avoided.

2.2.11 Renewable Energy Systems

Construction sites are surrounded by natural energy in the forms of wind, solar radiation, and geothermal heat. Renewable energy systems can be used to supplement or eliminate traditional heating, cooling, and electrical systems through the utilization of this natural energy. Components that encourage day lighting, passive and active solar heating, and on-site power generation are included in this category. Solar power can be utilized in many forms, both for heating and production of electricity. In many parts of the country, wind power is a feasible way to generate electricity and pump water.

Therefore by the use of renewable energy systems we can reduce the need for the traditional energy usage.

2.2.12 Longer Life

Materials with a longer life relative to other materials designed for the same purpose need to be replaced less often. This reduces the natural resources and energy required for manufacturing and the amount of money spent on installation and the associated labor. Durable materials that require less frequent replacement will require fewer raw materials and will produce less landfill waste over the building's lifetime.

The durability and maintenance consumption of materials is an important factor in analyzing a building's life-cycle costs.

Therefore materials with longer life, over a building's useful life are more cost-effective and environmentally friendly than materials that need to be replaced more often.

2.2.13 Reusability

The reusability of a material is a function of the age and durability of a material. Very durable materials may have many useful years of service left when the building in which they are installed is decommissioned, and may be easily extracted and reinstalled in a new site. Windows and doors, plumbing fixtures, and even brick can be successfully reused. Timber from old barns has become fashionable as a reclaimed material for new construction.

Therefore the reusability of a material reduces the need for newly manufactured products.

2.2.14 Recyclability

Many building materials that cannot be reused in their entirety can be broken down into recyclable components. Recyclability measures a material's capacity to be used as a resource in the creation of new products. Steel is the most commonly recycled building material, in large part because it can be easily separated from construction debris by magnets; glass is very easy to recycle: post-consumer glass is commonly used as a raw material in making window glass, ceramic tile, and brick. Concrete, unlike steel and glass, cannot be re-formed once set, but it can be ground up and used as aggregate in new concrete or as road bedding. Currently, very little concrete and glass from site demolition is recycled because of the difficulty in separating these materials from construction debris.

Therefore the recyclability of a product can reduce the embodied energy of that product (see table 1)

2.2.15 Biodegradability

The biodegradability of a material refers to its potential to naturally decomposing when discarded. Organic materials can return to the earth rapidly, while others, like steel, take a long time. An important consideration is whether the material in question will produce hazardous materials as it decomposes, either alone or in combination with other substances.

Therefore the biodegradability of a material is very important for the environmental impact.

3.3 SELECTION CRITERIAS OF SUSTAINABLE BUILDING MATERIALS

There are environmentally sustainable replacements for use in every building system by products selected from materials that are designed and manufactured with environmental considerations. The selection criteria include sustainability in regard to a wide range of environmental issues: raw material extraction and harvesting, manufacturing processes, construction techniques, and disposal of demolition waste.

Table 2 Key to the green features of sustainable building materials

Green features		
Manufacturing process(MP)	**Building operation (BO)**	**Waste management (WM)**
Waste reduction (WR)	Energy efficiency (EE)	Biodegradable (B)
Pollution prevention (P2)	Water treatment & conservation (WTC)	Recyclable (R)
Recycled (RC)	Nontoxic (NT)	Reusable (RU)
Embodied energy reduction (EER)	Renewable Energy Source (RES)	Others (O)
Natural materials (NM)	Longer Life (LL)	

This table 2 is a chart of the criteria, grouped by the affected building life-cycle phase. This chart helps compare the sustainable qualities of different materials used for the same purpose. The presence of one or more of these "green features" in a building material can assist in determining its relative sustainability.

3.3.1 Pre-Building Phase: Manufacture

The Pre-Building Phase describes the production and delivery process of a material up to, but not including, the point of installation. At this phase of a building material we can select the building materials by analyzing and assessing this features of a building material.

3.3.1.1Waste Reduction

This feature indicates that the manufacturer has taken steps to make the production process more efficient, by reducing the amount of scrap material that results.

3.3.1.2Pollution Prevention

This feature indicates that the manufacturer has reduced the air, water, and soil pollution associated with the manufacturing process.

3.3.1.3Recycled Content

This feature indicates that a product has been produced partially or entirely of post-industrial or post-consumer waste.

2.3.1.4 Embodied Energy Reduction

This feature indicates that a revision to a manufacturing process that saves energy by reducing the embodied energy of the material has been done.

2.3.1.5 Use of Natural Materials

This feature indicates that Natural materials require less processing and are less damaging to the environment.

3.3.2 Building Phase: Use

The Building Phase refers to a building material's useful life. At this phase of a building material we can select the building materials by analyzing and assessing this features of a building material.

2.3.2.1 Reduction in Construction Waste

This feature indicates that efficient use of materials is a fundamental principle of sustainability.

2.3.2.2 Energy Efficiency

This indicates feature that in making a building material environmentally sustainable the use of energy efficient materials can reduce the amount of artificially generated power that must be brought -to a building site.

2.3.2.3 Water Treatment/Conservation

This feature indicates that a reduction in the amount of water that must be treated by municipal septic systems, with the accompanying chemical and energy costs.

2.3.2.4 Use of Non-Toxic or Less-Toxic Materials

This feature indicates that materials with feature are less hazardous to construction workers and building occupants. .

2.3.2.5 Renewable Energy Systems

This feature indicates that this energy system replace traditional building systems that are dependent on the off-site production of electricity and fuel by the use of Solar, wind, and geothermal energy utilizing the natural resources already present on a site.

2.3.2.6 Longer Life

This feature indicates that a reduction in the use of natural resources required for manufacturing and the amount of money spent on installation and the associated labor.

3.3.3 Post-Building Phase: Disposal

The Post-Building Phase refers to the building materials when their usefulness in a building has expired. At this phase of a building material we can select the building materials by analyzing and assessing this features of a building material.

2.3.3.1 Reusability

This feature indicates the reusability and durability of a material.

2.3.3.2 Recyclability

This feature indicates the recyclability measures of a material's capacity to be used as a resource in the creation of new products.

2.3.3.3 Biodegradability

This feature indicates whether the material in question will produce hazardous materials as it decomposes, either alone or in combination with other substances.

CHAPTER THREE METHODOLOGY

METHODOLOGY OF THE STUDY

This case study is supported by a methodology approach which is a comprehensive and thorough literature review. Information was gathered from the literature available in academic libraries and on the Internet, including articles, books, publications, reports, etc…

CHAPTER FOUR RESULT AND DISCUSSION

1.1 GENERAL INFORMATION

This section mainly reviews the green features of some examples of building material at different parts of a building. These parts of a building are Site and Landscaping, Foundations and Structural Framing.

1.1.1 SITE AND LANDSCAPING

Recycled plastic has been developed into a wide range of landscaping products. Plastic lumber is widely used in outdoor furniture and decking. This lumber is made by shredding and reforming post-consumer plastic containers such as pop bottles and milk jugs. Some brands incorporate waste or recycled wood as well. Plastic lumber has advantages over wood in that it is impervious to moisture and will not warp, rot, or check. It is available as dimensional stock, or in a wide variety of manufactured garden furniture and accessories. Traffic stops and bumpers are also being made from recycled plastic, replacing concrete and asphalt.

By recycling plastic, a major contributor to landfill waste is put to a new use and raw materials are conserved. Water conservation also results, because recycling plastic requires less water than processing new plastic, wood, or concrete. When used in soil erosion control products, recycled plastic also prevents topsoil loss and the resulting consequences of increased water turbidity. The recycled plastic products can themselves be recycled when their useful life has ended. Because the material is inert, it will not degrade into toxic substances if discarded in landfills.

Table 3 Green features of plastic lumber

MP	BO	WM
WR		
	WTC	R
RC		RU
EER	NY	
	LL	

1.1.2 FOUNDATIONS

Poured-in-place concrete and concrete block foundations have long been a staple in the construction industry. They provide thermal mass insulation and have a long life. Significant improvements have been made that reduce the installation waste produced on-site and increase the insulation value of these foundation systems. These systems are collectively known as super-insulated foundations.

Two of the major drawbacks of poured-in-place concrete are the time and materials required to erect formwork. Generally, plywood and dimensional lumber are used to construct the forms, then discarded after the concrete has set. This essentially wastes the energy involved in producing the wood and plywood, which can be high given the drying of wood and the petroleum used to make the binding resins. Furthermore, because of the resins, the plywood is difficult to recycle and usually ends up in a landfill. Permanent formwork has been developed using rigid plastic foam The foam sheets or blocks are used to contain the concrete during pouring, and improve compressive strength by retaining the heat produced as the concrete sets, resulting in a 25% stronger wall.

Table 4 Green features of insulated foundations

MP	BO	WM
WR	EE	
	LL	

1.1.3 STRUCTURAL FRAMING

As the price of virgin wood rises and the quality declines, steel framing is becoming an economical alternative to wood stud framing in residential construction. It has been long favored in commercial construction for its ease of assembly and uniform quality. Until recently, the price of steel studs and the customized nature of home design made its use impractical. However, because steel is stronger, fewer members are needed to support the same load. Although steel has a very high embodied energy content, it can easily be reused and recycled.

Table 5 Green features of steel framing

MP	BO	WM
		B
		R
RC	NT	RU
NM	LL	

1.2 ANALYZING BUILDING MATERIALS

The data-gathering part of the material-selection process is currently the most difficult, as sustainable building materials compose a small percentage of the market. Manufacturers' product data sheets are still the best source for specific brands, but it must be recognized that these are promotional materials. Product specification sheets, produced for marketing purposes, may not provide objective data, and the data may not be easily comparable with competitive products. Architects and engineers are in a position to encourage the production of a wider variety of sustainable materials by contacting manufacturers for more specific information and refusing to specify materials made through highly polluting processes. Insist that product data sheets list the chemicals that are used in the manufacturing process or that will be emitted by a material over time. Fire safety is also an issue, as many otherwise benign substances (like foam rubber) can become toxic when exposed to high heat or flame. Contacting manufacturers for more specific information serves two purposes: it increases the architect's and engineer's knowledge base of materials, and it makes the manufacturer aware of interest in sustainable materials. Only through knowledge of the entire life cycles of otherwise comparable building products can an intelligent, informed choice be made. By insisting that manufacturers reveal the toxicity levels and environmental impact of the manufacturing process, architects and engineers can also apply pressure on manufacturers to make their materials and manufacturing methods more sustainable.

CHAPTER FIVE CONCLUSION AND RECOMMENDATION

3.1 CONCLUSION

We can assess the environmental sustainability of a construction product through a life cycle assessment (life-cycle analysis, eco balance, and cradle-to-grave analysis). A life cycle assessment is structured in to four phases the goal and scope phase, the inventory analysis phase, the impact assessment phase and the interpretation phase.

The features of a sustainable building material are the bases in the selection criteria for sustainable building material. These features are pollution prevention measures, Waste Reduction Measures in Manufacturing, Recycled Content, Embodied Energy Reduction, Use of Natural Materials, Reduction of Construction Waste, Local Materials, Energy Efficiency, Water Treatment/Conservation, Use of Non-Toxic or Less-Toxic Materials, Renewable Energy Systems, longer life, reusability, recyclability and biodegradability.

By assessing and analyzing all the features of a building material we can select a material that is suitable for a curtain building in doing that we are preventing or reducing environmental degradation caused by a building material throughout their life cycle.

3.2 RECOMMENDATION

The recommendations which result from this case study from an extensive review of the available literature. Is that by becoming more involved in the material choices the architects and engineers gain more control over the quality and sustainability of building materials. And the only way to do that is by gathering data, analyzing and assessing all features of a building material. This in result gives us a development in the sustainable building materials which in result gives us a sustainable environment.

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