A Detailed Report on Environmental Impact of Construction Materials and Practices

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ABSTRACT OF DISSERTATION

Buildings, building materials and components consume nearly 40 percent of global energy annually in their life cycle stages, such as production and procurement of building materials, construction, use and demolition. The total life cycle energy of a building constitutes the embodied as well as the operational energy.

Most current databases of embodied energy include data that are derived using guidelines set forth by the International Standardization Organization (ISO) for Life Cycle Assessment (LCA). Most research studies performed either energy analysis or LCA to calculate embodied and operational energy in the whole life cycle of a building. Studies that performed LCA mention either using ISO LCA standards or none. However, studies that are skeptical about using LCA for assessing buildings in environmental impact terms exist.

This thesis work gives an insight of the environmental hazards faced due to the consumption of uncontrolled construction materials. Although the achievement is to reduce these impact but with the increase in consumption of construction materials these achievement looks unpromising. To appease these unfavorable environmental impacts are the more realistic ultimate goal.

In biology and ecology the environment is all of the natural materials and living things, including sunlight. This is also called the *natural environment*. The important things in the environment that we value are called natural resources. For example fish, sunlight, and forests. These are *renewable* natural resources because more grow naturally when we use them. *Non-renewable* natural resources are important things in the environment that do not come back naturally, for example coal and natural gas.

A sustainability issue arises whenever a valued system, object, process or attribute is under threat. The existence of the valued system, object, process or attribute could be threatened or its quality could be threatened with serious decline. In other words there is a sustainability issue whenever there is something that is valued that faces the risk of not being maintained.

The simplest point at which to begin evaluating the impact of the construction industry is to look at its consumption of energy and greenhouse gas emissions. The biggest culprits in terms of climate change are the materials that form the basis of modern construction – concrete and steel. Twice as much concrete is used in formal construction around the world than the total of all other building materials – including wood, steel, plastic and aluminum.

Cement production is, after the burning of fossil fuels, the biggest anthropogenic contributor to greenhouse gas emissions. Cement kilns have been identified as a stationary source of nitrogen oxides, releasing more than 25 tons per year. Although cement makes up only 12-14% of the final concrete mix, further embodied energy comes from the transportation and extraction of aggregates and, in the case of reinforced concrete, the manufacturing of steel.

As early as 1896, a Swedish chemist already proposed that the changing atmospheric carbon dioxide concentration was the major cause of global temperature fluctuations, the carbon dioxide concentration in 1765 was about 280 parts per million by volume but it has increased to approximately 364 ppm in 2009.

Apart from the increased atmospheric concentration of carbon dioxide, atmospheric concentrations of other greenhouse gases such as methane, nitrous oxide and chlorofluorocarbons are also increasing as a result of human activities.

It is estimated that there will be an average increase in sea level of about 6cm per decade for a temperature rise of between 1.5 to 5.5°C. The sea levels are expected to rise by about 0.5m by 2100.

The high concentration of carbon dioxide in the atmosphere also increases the rate of plant loss, that is, loss of biodiversity, another environmental problem that threatens human existence.

Selection of materials can significantly reduce embodied energy and CO_2 which play an important role in reducing the impact of climate change resulting from emission. The sustainable buildings should emphasis on use of recycled materials like bricks and concrete, natural ventilation using mixed mode design. Mixed mode design is a concept where mechanical and natural ventilations are provided for optimum comfort condition, which is 26 degree Celsius

Chapter-1

(a) PROJECT BACKGROUND

Buildings, building materials and components consume nearly 40 percent of global energy annually in their life cycle stages, such as production and procurement of building materials, construction, use and demolition. The total life cycle energy of a building constitutes the embodied as well as the operational energy. Embodied energy is the total amount of energy consumed during the production, use (renovation and replacement) and demolition phase, whereas operational energy is the energy required to operate the building in processes, such as space conditioning, lighting and operating other building appliances.

Building, a high embodied energy material may also reduce a building‘s operational energy consumption. For an accurate comparison and informed decision, the embodied energy data of two materials or components should be measured on the basis of similar parameters.

Most current databases of embodied energy include data that are derived using guidelines set forth by the International Standardization Organization (ISO) for Life Cycle Assessment (LCA). Most research studies performed either energy analysis or LCA to calculate embodied and operational energy in the whole life cycle of a building. Studies that performed LCA mention either using ISO LCA standards or none. However, studies that are skeptical about using LCA for assessing buildings in environmental impact terms exist.

Literature suggests that development of a set of standards or protocol could minimize problems of variation in energy data and could introduce accuracy and completeness to the embodied energy figures. ISO LCA standards do not provide complete guidance to the process of LCA. Moreover, some issues, such as system boundary definition and data quality, remain unresolved. This paper performs a review of literature in the realm of embodied energy and Life Cycle Assessment (LCA) and provides a survey of existing international LCA standards.

(b) Overview

The increase of unstable activities by human is resulting in some serious damages like tsunami, wildfires, flooding and drought due to global warming, rising of sea level, depletion of ozone layer causing increasing threats of cancer and land loss due to contamination of soil. Construction industries have a larger part in contributing these environmental problems. The extensive resource depletion is occurred due to the usage of large volumes of construction materials. All round the world construction materials generate million tons of waste annually. These construction materials require high embodied energy resulting with large CO_2 (Carbon Dioxide) emissions. The embodied energy of steel is about 32 MJ/Kg and for cement is about 7.8 MJ/Kg Scientific and Industrial Research Organization). The highest CO_2 producing material is cement and a large amount of CO_2 is produced in the processing of construction materials and in the transport of these materials. If the consumption of the construction materials remains the same all around the world then by the year 2050 the production of the cement in the world could reach 3.5 billion metric tons. But annually the production and consumption of the construction materials are increasing simultaneously, if this is the case then the production of cement itself annually could reach over 5 billion metric tons with approximately about 4 billion tons of CO_2 (carbon dioxide) emissions. Due to the abundant usage of the construction materials the impact of these materials is dominated than from the impact of the other sources.

(c) Problem discussion:

This thesis work gives an insight of the environmental hazards faced due to the consumption of uncontrolled construction materials. Although the achievement is to reduce these impact but with the increase in consumption of construction materials these achievement looks unpromising. To appease these unfavorable environmental impacts are the more realistic ultimate goal.

By reducing the consumption of construction materials or by reducing the impacts caused by each construction material the unfavorable environmental impacts can be alleviated to some extent. This can be done in two methods to diminish the environmental hazards.

1. Abate the consumption of construction materials: The natural resources are gradually reducing with growing population and people‘s demand. By recycling and reusing the construction materials will avoid the need for new resources and thus saving the natural resources or reducing the consumption of construction materials.
2. Selection of construction materials: Designer plays an important role in selection of the material. This can be done by the environmental performance of the material. To evaluate the judgment a tool should be available to the designer for selecting material to accomplish the goal of minimizing the environmental impacts.

(d) Purpose of this study:

The purpose of this thesis work is to give an overview and to understand deeply the concept of ― Environmental Impact of Construction Materials and Practices‖ which is defined and interpreted in theory. In order to get an overview theoretical study is conducted which is carrying out by research work on relevant literature through textbooks, scientific articles, internet etc.

❖ Chapter-2

➢ Literature Review

[1] Suzzane Goldberg in Yokohama, Japan

The head of the United Nations climate panel said he hoped its report on the rising threat of climate change would ―jolt people into action.

The report, released on Monday, is a 2,600-page catalogue of the risks to life and livelihood from climate change – now and in the future.
Rajendra Pachauri, who has headed the IPCC for 12 years, said he hoped it would push government leaders to deal with climate change before it is too late.

since the last report in 2007, and the findings make an increasingly detailed picture of how climate change – in tandem with existing fault lines such as poverty and inequality – poses a much more direct threat to life and livelihoods.
This was reflected in the language. The summary mentioned the word ―risk‖ more than 230 times, compared to just over 40 mentions seven years ago, according to a count by the Red Cross.

[2] Manish Kumar Dixit

Building materials have the promising potential of significantly reducing energy use in the construction industry as EE is gaining importance among researchers, professionals, builders and material manufacturers. Current research efforts in the form of embodied energy energy inventories and methodologies suffer from inaccuracy and unreliability of energy data and thus are incomplete and inaccurate. This problem is due to parameters that vary and is related to various stages of embodied energy analysis. There is a stated and identified need to address the problem of variation and inconsistency by identifying and eliminating impacts of differing embodied energy parameters.

His paper identifies and presents a set of parameters that differ and which cause variation and inconsistency in embodied energy figures. This paper discusses the existing state of unclear interpretation about embodied energy and provides an idea about the inherent variation. The literature indicates that the geographic location is stated by most of the studies while feedstock energy consideration is the one least stated. These parameters, if addressed, could result in a consistent, translatable and comparable database of embodied energy of building materials. This paper points out the need to evolve a standardized approach to data collection (embodied energy) that includes necessary guidelines and requirements to address difference of parameters, which could be followed by research and practice worldwide. Once the industry has a standard template for collecting and analyzing information, an energy economy that accounts for most of the energy embodied in a building will be useful to compare products and buildings regarding effective use of energy.

❖ Chapter-3

➢ Methodology-

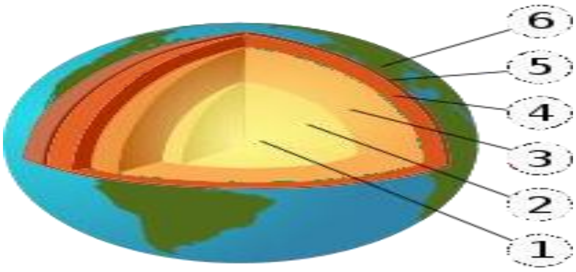
ENVIRONMENT STUDY

Natural Environment

In biology and ecology the environment is all of the natural materials and living things, including sunlight. This is also called the *natural environment*. The important things in the environment that we value are called natural resources. For example fish, sunlight, and forests. These are *renewable* natural resources because more grow naturally when we use them. *Non-renewable* natural resources are important things in the environment that do not come back naturally, for example coal and natural gas.

The natural environment encompasses all living and non-living things occurring naturally on Earth or some region thereof. It is an environment that encompasses the interaction of all living species.

Composition of Natural Environment



Earths layered structure.

(1) Inner core;

(2) Outer core;

(3) Lower mantle;

(4) Upper mantle;

(5) Lithosphere;

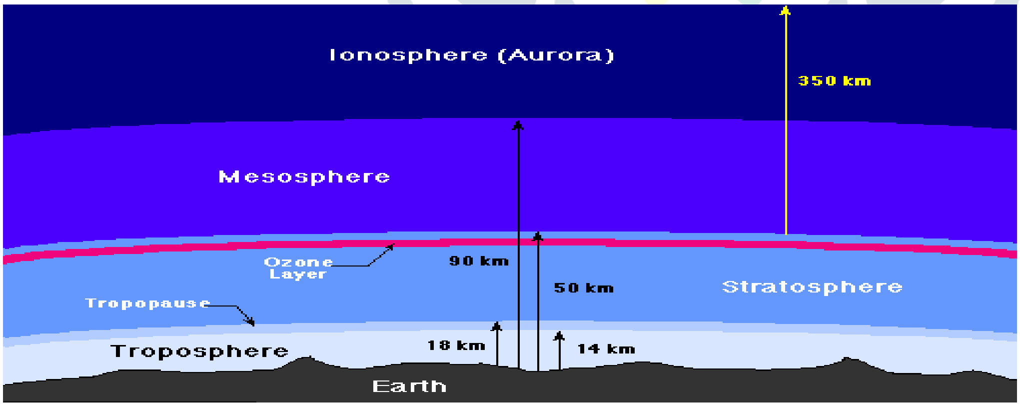
(6) Crust.

Earth science generally recognizes 4 spheres, the lithosphere, the hydrosphere, the atmosphere, and the biosphere as correspondent to rocks, water, air, and life. Some scientists include, as part of the spheres of the Earth, the cryosphere (corresponding to ice) as a distinct portion of the hydrosphere, as well as the pedosphere (corresponding to soil) as an active and intermixed sphere.

Atmospheric layers

1. Principal layers

Earth's atmosphere can be divided into five main layers. These layers are mainly determined by whether temperature increases or decrease with altitude. From highest to lowest, these layers are:

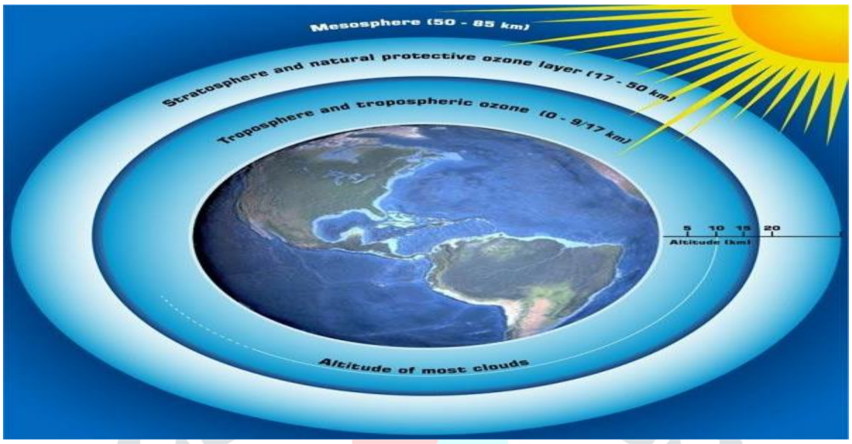


- ***Exosphere***: The outermost layer of Earth's atmosphere extends from the exobase upward, mainly composed of hydrogen and helium.
- ***Thermosphere***: The top of the thermosphere is the bottom of the exosphere, called the exobase. Its height varies with solar activity and ranges from about 350–800 km (220–500 mi; 1,150,000–2,620,000 ft). The International Space Station orbits in this layer, between 320 and 380 km (200 and 240 mi).
- ***Mesosphere***: The mesosphere extends from the stratopause to 80–85 km (50– 53 mi; 262,000–279,000 ft). It is the layer where most meteors burn up upon entering the atmosphere.
- ***Stratosphere:*** The stratosphere extends from the tropopause to about 51 km (32 mi; 167,000 ft). The stratopause, which is the boundary between the stratosphere and mesosphere, typically is at 50 to 55 km (31 to 34 mi; 164,000 to 180,000 ft).
- ***Troposphere***: The troposphere begins at the surface and extends to between 7 km (23,000 ft) at the poles and 17 km (56,000 ft) at the equator, with some variation due to weather. The troposphere is mostly heated by transfer of energy from the surface, so on average the lowest part of the troposphere is warmest and temperature decreases with altitude. The tropopause is the boundary between the troposphere and stratosphere.

2. Other layers

Within the five principal layers determined by temperature are several layers determined by other properties.

- The ozone layer is contained within the stratosphere. It is mainly located in the lower portion of the stratosphere from about 15–35 km (9.3–21.7 mi; 49,000– 115,000 ft), though the thickness varies seasonally and geographically. About 90% of the ozone in our atmosphere is contained in the stratosphere.
- The ionosphere, the part of the atmosphere that is ionized by solar radiation, stretches from 50 to 1,000 km (31 to 621 mi; 160,000 to 3,280,000 ft) and typically overlaps both the exosphere and the thermosphere. It forms the inner edge of the magnetosphere.
- The homosphere and heterosphere: The homosphere includes the troposphere, stratosphere, and mesosphere. The upper part of the heterosphere is composed almost completely of hydrogen, the lightest element.
- The planetary boundary layer is the part of the troposphere that is nearest the Earth's surface and is directly affected by it, mainly through turbulent diffusion.



Climate

Climate encompasses the statistics of temperature, humidity, atmospheric pressure, wind, rainfall, atmospheric particle count and numerous other meteorological elements in a given region over long periods of time. Climate contrasted to weather, which is the present condition of these same elements over periods up to two weeks.

Climates can be classified according to the average and typical ranges of different variables, most commonly precipitation.

Weather

Weather is a set of all the phenomena occurring in a given atmospheric area at a given time. Most weather phenomena occur in the troposphere, just below the stratosphere. Weather refers, generally, to day-to-day temperature and precipitation activity, whereas climate is the term for the average atmospheric conditions over longer periods of time.

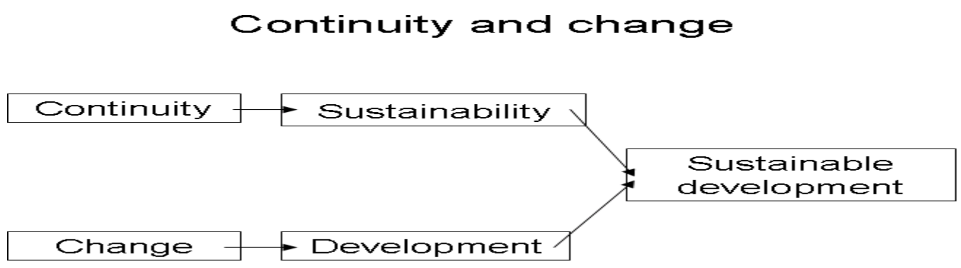
Human attempts to control the weather have occurred throughout human history, and there is evidence that human activity such as agriculture and industry has inadvertently modified weather patterns.

ENVIRONMENTAL SUSTAINABILITY

Sustainability is broadly defined as ―meeting the needs of the present generation without compromising the ability of future generations to meet their own needs. Environmental sustainability involves making decisions and taking action that are in the interests of protecting the natural world, with particular emphasis on preserving the capability of the environment to support human life.
Whenever there are such risks there is a degree of urgency to take action these sustainability programs need to operate on an adequate scale and need to continue operating reliably for as long as the threats continue.

Some of the issues that pose major environmental sustainability problems include:

- Destruction of the living environments (habitats) of native species.
- Discharge of polluting chemicals and other materials into the environment.
- Emission of greenhouses gases into the atmosphere than can cause climate change.
- Depletion of low cost oil and other fossil fuels.
- Some environmental issues are largely of local significance while others have regional or even global relevance.



Sustainability is about *continuity* and development is about *change*. There are many things about life that we want to sustain (maintain) and many that we want to change. So it makes sense to create the notion of '*sustainable development*' that combines desired change and desired continuity - for example we might change exploitation, unhappiness, poverty, destructiveness, etc. and sustain the rest of nature, trust, tolerance, honesty, happiness, health etc.

- **sustainability issue-**

A sustainability issue arises whenever a valued system, object, process or attribute is under threat. The existence of the valued system, object, process or attribute could be threatened or its quality could be threatened with serious decline. In other words there is a sustainability issue whenever there is something that is valued that faces the risk of not being maintained.

Environmental Sustainability Index (ESI), which ranks countries based on such measures as health, governance, technology, and international cooperation and evaluates —the likelihood that a country will be able to preserve valuable environmental resources effectively over the period of several decades. Sustainable development is the watchword of the day, which means that care must be taken to preserve existing environmental resources for the benefit of future generations. At the risk of failure, India may also provide a shining model of how to simultaneously advance democracy, economic growth, quality of life, and environmental health.

For all practical purposes that means 'forever '.Living species seem to last on average a few million years before becoming extinct though some may evolve into new species. So if we maintained a natural extinction rate for species it is so low that for practical purposes we would need to manage in the here and now *as if* we wanted all species to survive, effectively 'forever'. Sustaining the recycling of certain materials may only need to continue for as long as those material types are needed technologically, and depending on the pace of technical change this could be for centuries or for decades.

Chapter-4

Site Study & calculation

THE IMPACT OF CONSTRUCTION INDUSTRIES

The industry‘s environmental impact is the most measurable, but its socio-economic impact should not be negated. Sustainable construction in the developing countries tends to focus on the relationship between construction and human development, often marginalizing the environmental aspects.

The physical environment and the construction sector are linked principally by the demands made by the latter on global natural resources, and this assumes huge environmental significance with the rapid growth in global population and the attendant implications for natural resources.

The simplest point at which to begin evaluating the impact of the construction industry is to look at its consumption of energy and greenhouse gas emissions. The biggest culprits in terms of climate change are the materials that form the basis of modern construction – concrete and steel. Twice as much concrete is used in formal construction around the world than the total of all other building materials – including wood, steel, plastic and aluminum.

Cement production is, after the burning of fossil fuels, the biggest anthropogenic contributor to greenhouse gas emissions. Cement kilns have been identified as a stationary source of nitrogen oxides, releasing more than 25 tons per year. Although cement makes up only 12-14% of the final concrete mix, further embodied energy comes from the transportation and extraction of aggregates and, in the case of reinforced concrete, the manufacturing of steel.

Steel is one of the most energy-intensive materials. Together, the production of iron and steel is responsible for 4.1% of global energy use. The manufacturing and final use of both these materials can also be very water-intensive. Construction activities, whether through the manufacturing of construction materials, or through the operational activities of actual construction, also lead to a number of other environmental problems. These include noise pollution, dust, and hazardous contamination through toxic waste.

The production of iron, steel and non-ferrous metals, as well as the production of other construction materials such as cement,

glass, lime and bricks, is responsible for 20% of annual dioxin and furan emissions.
This exclude emissions due to the production and use of PVC and other chlorinated substances used in the construction industry as paints, sealants, plastics and wood preservatives, for which specific figures are not yet available. Road transport infrastructure, especially road paving with asphalt, contributes a further one percent of annual dioxin emissions. The bulk of dioxin emissions (69%) come from the incineration of municipal waste.

This life-cycle concept refers to all activities from extraction of resources through product manufacture and use and final disposal or recycle, i.e. from ―cradle to grave.
Risk should be identified and steps taken to minimize potential pollution. The construction industry must consider enhancing or at least protecting biodiversity as it ―considers all things and their habitats‖ and there is an obligation to consider biodiversity in developments in terms of good design and material selection.
If the construction industry continues to overuse these natural resources, a limit on economic growth will eventually emerge. In other words, the destruction of the environment will inevitably affect the construction industry.

Apart from waste generation, the building industry rapidly growing world energy use and the use of finite fossil fuel resources has already raised concerns over supply difficulties, exhaustion of energy resources and heavy environmental impacts. Building material production consumes energy, the construction phase consumes energy, and operating a completed building consumes energy for heating, lighting, power and ventilation. The existing building stock in European countries accounts for over 40% of final energy consumption in the European Union (EU) member states, of which residential use represents 63% of total energy consumption in the buildings sector. The built environment is responsible for 50% of the total UK energy consumption; 45% to heat, light and ventilate buildings and 5% to construct them, while arguably more than 50% of all UK carbon emissions can be attributed to energy use in buildings (including residential and business emissions) .

- **Deforestation and its associated impacts:**

Timber for construction and related industries is often harvested from indigenous forests and only minimally replaced, causing soil erosion, siltation of watercourses, and reduced precipitation and its concomitant problems. These indirect impacts generate growing regional inequalities, impoverishment, and underemployment. Site design and the impact of the actual construction process on the natural environment remain common problems.
In the process, the natural green system has been destroyed and compaction has taken place to a level that prevents air movement in the soil, even after construction has been completed. The existing natural environment has in many cases been destroyed beyond repair.
The construction industry also has a huge impact on agricultural land. Soil erosion and other forms of land degradation now rob the world of 70-140000 km^2/year of farming land. Urbanization alone is responsible for the loss of 20-40000 km^2/year. Again, the impact is most dire in developing countries with poor-quality soils, such as most African countries.

- **Climate change and its associated impacts:**

Climate change has become synonymous with global warming and it is caused by the build-up of greenhouse gases, which trap energy on the Earth's surface. Significant climate change over the next century is expected.
As early as 1896, a Swedish chemist already proposed that the changing atmospheric carbon dioxide concentration was the major cause of global temperature fluctuations, the carbon dioxide concentration in 1765 was about 280 parts per million by volume but it has increased to approximately 364 ppm in 2009.
Apart from the increased atmospheric concentration of carbon dioxide, atmospheric concentrations of other greenhouse gases such as methane, nitrous oxide and chlorofluorocarbons are also increasing as a result of human activities.
It is estimated that there will be an average increase in sea level of about 6cm per decade for a temperature rise of between 1.5 to 5.5°C. The sea levels are expected to rise by about 0.5m by 2100.
The high concentration of carbon dioxide in the atmosphere also increases the rate of plant loss, that is, loss of biodiversity, another environmental problem that threatens human existence.

- **Sand Mining & its Associated Impact**

Excessive in stream sand-and-gravel mining causes the degradation of rivers. In stream mining lowers the stream bottom, which may lead to bank erosion. Depletion of sand in the streambed and along coastal areas causes the deepening of rivers and estuaries, and the enlargement of river mouths and coastal inlets. It may also lead to saline-water intrusion from the nearby sea. The effect of mining is compounded by the effect of sea level rise. Any volume of sand exported from streambeds and coastal areas is a loss to the system.

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- **How will project operation affect the geology, soils, and ground water**

- **Direct Effects-**

Long-term geology, soils, and groundwater-related effects could occur during normal operations of SR 167. The project will be designed based on the available subsurface information, design procedures and criteria approved and the existing site conditions. If subsurface conditions at the site are different from those disclosed during the field explorations, or site conditions change during the life of the project, future effects to the site could occur.

- **Seismic Considerations-**

Slopes an earthquake could trigger landslides on steep slopes, settlement, or liquefaction in alluvial deposits, that could slide or slough during an earthquake include new fill embankments and cut slopes. Alluvial deposits that are potentially susceptible to liquefaction during a seismic event underlie the project area. If liquefaction occurs beneath or alongside foundation structures, loss of bearing capacity, settlement, and lateral displacement may occur. If liquefaction occurs beneath proposed embankments, slope instability and settlement could damage the existing roadway and adjacent facilities.

- **Settlement-**

Down drag occurs when the skin friction force is in the same direction as the axial load. When the settlement of the surrounding soils exceeds the downward movement of a pile or shaft negative skin friction occurs. This typically happens when a pile or shaft passes through an under consolidated layer of fill that is consolidating under its own weight, but can also be a result of lowering the water table or additional surcharge loads being applied. Cuts into Existing Slopes Construction activities will require that cuts into existing slopes be made for storm water detention ponds. These cuts may experience erosion and surface sloughing over the lifetime of the project.

- **Permanent Drainage-**

Permanent drainage facilities may result in increased water flow to existing culverts or drainage ditches. Sediment from slope erosion may accumulate in ditches, culverts, swales, and other drainage features. Water that overflows or is incorrectly directed onto slopes or properties could cause erosion, landslides, and other effects.

- **Does cement manufacturing generate CO_2?**

- As with all industrial processes requiring energy, manufacturing cement does result in the generation of CO_2.
- Cement is manufactured from a combination of naturally occurring minerals - calcium (60% by weight) mainly from limestone or calcium carbonate, silicon (20%), aluminum (10%), iron (10%) and small amounts of other ingredients and heated in a large kiln to over 1500° C (2700^{0}F) to convert the raw materials into clinker.
- For the most part, CO_2 is generated from two different sources during the cement manufacturing process:

  - Use of fossil fuels in the burning process;

  - Calcinations

The most commonly used cement is called Portland cement. It contains about 92% to 95% clinker by weight.

- Between 50% and 60% of the CO_2 emitted is a result of calcinations of calcium carbonate raw materials, a necessary part of the manufacturing process. The remaining CO_2 emitted is a result of burning fossil fuels such as coal and natural gas to heat the raw materials in the kiln.
- The U.S. cement industry accounts for approximately 1.5% of U.S. CO_2 emissions, well below other sources such as heating and cooling our homes (21%), heating and cooling our buildings (19%), driving our cars and trucks (33%) and industrial operations (27%).

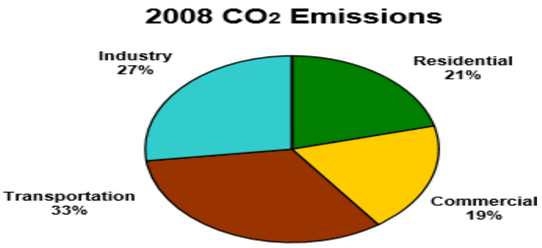


Figure 2008 U.S. CO_2 emissions by category.

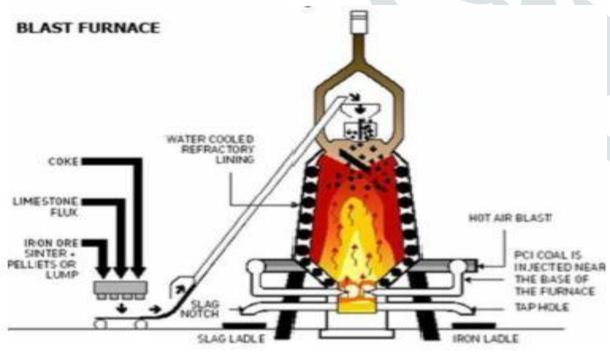
- Global CO_2 emissions from cement production (377 million metric tons of carbon in 2007) represent 4.5% of global CO_2 releases from fossil-fuel burning and cement production.

➢ How much CO2 is embodied in concrete?

Concrete uses about 7% and 15% cement by weight depending on the performance requirements for the concrete. The average quantity of cement is around 250 kg/m3 (420 lb/yd^3). One cubic meter (m^3) of concrete weighs approximately 2400 kg (1 cubic yard weighs approximately 3800 lb). As a result, approximately 100 to 300 kg of CO_2 is embodied for every cubic meter of concrete (170 to 500 lb per yd^3) produced or approximately 5% to 13% of the weight of concrete produced, depending on the mix design. A significant portion of the CO_2 produced during manufacturing of cement is reabsorbed into concrete during the product life cycle through a process called carbonation. One research study estimates that between 33% and 57% of the CO_2 emitted from calcinations will be reabsorbed through carbonation of concrete surfaces over a 100-year life cycle.

➢ Basic Oxygen Furnace (BOF):

To produce new steel, basic oxygen furnace (BOF) uses 25% to 35% old steel. Where this furnace produces products like encases of refrigerators, automotive cover etc whose major characteristic is drawability. In 2006 by Steel Recycling Institute, to produce 46,802,100 tons of raw steel the basic oxygen furnace (BOF) consumed a total of 13,509,000 tons of ferrous scrap where 1,000,000 tons of these ferrous scrap tons had been produced as non-salable steel products. In steel industry, these tons of scraps are classified as ―home scrap‖ which is a mixture of pre-consumer scrap and runaround scrap.



Blast Furnace

➢ EMBODIED ENERGY

Embodied energy is the total energy required for the extraction, processing, manufacture and delivery of building materials to the building site. Energy consumption produces CO_2, which contributes to greenhouse gas emissions, so embodied energy is considered an indicator of the overall environmental impact of building materials and systems. Unlike the life cycle assessment, which evaluates all of the impacts over the whole life of a material or element, embodied energy only considers the front-end aspect of the impact of a building Material. It does not include the operation or disposal of materials.

The total life cycle energy of a building includes both embodied energy and operating energy

(1) ***Embodied energy*** *(EE)*: sequestered in building materials during all processes of production, on-site construction, and final demolition and disposal

(2) ***Operating energy*** (OE): expended in maintaining the inside environment through processes such as heating and cooling, lighting and operating appliances.

Until recently, only operating energy was considered, owing to its larger share in the total life cycle energy. However, due to the advent of energy efficient equipment and appliances, along with more advanced and effective insulation materials, the potential for curbing operating energy has increased and as a result, the current emphasis has shifted to include embodied energy in building materials.

➢ Interpretation of embodied energy

These stages consist of raw material extraction, transport, manufacture, assembly, installation as well as its disassembly, deconstruction and decomposition. The energy consumed in production (in conversion and flow as proposed by koskela is called the –embodied energy of the material and is the concern of energy consumption and carbon emissions.
Likewise, a more comprehensive definition, provided by Baird, 1994; Edwards and Stewart, 1994; Howard and Roberts, 1995; Lawson; Cole and Kernan, 1996 (as cited in Ding), explains that –embodied energy comprises the energy consumed during the extraction and processing of raw materials, transportation of the original raw materials, manufacturing of building materials and components and energy use for various processes during the construction and demolition of the building. These definitions represent differences of opinion about the system boundaries to be included in embodied energy analyses.

Direct energy

Direct energy is consumed in various on-site and off-site operations like construction, prefabrication, transportation and administration.
Construction and assembly on-site: Energy inputs during the assembly of building materials and components on-site;
Prefabrication off-site: Building components that are prefabricated off-site that consume energy in the process
Transportation: Transportation involved in construction and assembly on-site and prefabrication off-site.

Indirect energy

Indirect energy is mostly used during the manufacturing of building materials, in the main process, upstream processes and downstream processes and during renovation, refurbishment, and demolition.
Initial embodied energy: Energy used during production of materials and components of a building, including raw material procurement, building material manufacturing and final product delivery to construction-site;

- ***Recurrent embodied energy***: Energy used in various processes for maintenance and refurbishment of buildings (building materials and building components) during their useful life;
- ***Demolition energy***: Energy necessary for deconstruction of building and disposing of building materials
- ***Operating energy***: Energy required in the building for operating various electrical and mechanical services.

➢ Why reduce embodied energy?

Embodied energy must be considered over the lifespan of a building, and in many situations, a higher embodied energy building material or system may be justified because it reduces the operating energy requirements of the building. For example, a durable material with a long lifespan such as aluminum may be the appropriate material selection despite its high embodied energy. As the energy efficiency of building increases, reducing the energy consumption, the embodied energy of the building materials will also become increasingly important.

➢ What is Life Cycle Assessment?

Life-cycle assessment (LCA, also known as life-cycle analysis, Eco balance, and cradle-to-grave analysis) is 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). The embodied energy of a typical building product is derived from the energy associated with the steps in its lifecycle from extraction of materials, through processing and manufacture, to transportation and construction, and in some cases its eventual disposal and reuse/recycle – this is often termed _cradle-to grave‘. The process of analyzing and quantifying all these steps is known as Life Cycle Assessment (LCA).

Embodied energy is just one of the environmental impacts associated with a building product‘s lifecycle; others include extraction of materials, water usage, pollution and toxic by-products from production etc. LCA is the basis of the assessment of sustainable materials and is at the heart of standard reference methods in this area.

LCAs can help avoid a narrow outlook on environmental concerns by:

- Compiling an inventory of relevant energy and material inputs and environmental releases;
- Evaluating the potential impacts associated with identified inputs and releases;

- Interpreting the results to help make a more informed decision.

There are two main types of LCA. Attritional LCAs seek to establish the burdens associated with the production and use of a product, or with a specific service or process, at a point in time (typically the recent past). Consequential LCAs seek to identify the environmental consequences of a decision or a proposed change in a system under study (oriented to the future), which means that market and economic implications of a decision may have to be taken into account. Social LCA is under development as a different approach to life cycle thinking intended to assess social implications or potential impacts. Social LCA should be considered as an approach that is complementary to environmental LCA.

The procedures of life cycle assessment (LCA) are part of the ISO 14000 environmental management standards: in ISO 14040:2006 and 14044:2006. S(ISO 14044 replaced earlier versions of ISO 14041 to ISO 14043.) GHG product life cycle assessments can also comply with standards such as PAS 2050 and the GHG Protocol Life Cycle Accounting and Reporting Standard.

Life cycle inventory-

Life Cycle Inventory (LCI) analysis involves creating an inventory of flows from and to nature for a product system. Inventory flows include inputs of water, energy, and raw materials, and releases to air, land, and water.
To develop the inventory, a flow model of the technical system is constructed using data on inputs and outputs. The flow model is typically illustrated with a flow chart that includes the activities that are going to be assessed in the relevant supply chain and gives a clear picture of the technical system boundaries.

Inventory flows can number in the hundreds depending on the system boundary. For product LCAs at either the generic (i.e., representative industry averages) or brand- specific level, that data is typically collected through survey questionnaires. At an industry level, care has to be taken to ensure that questionnaires are completed by a representative sample of producers, leaning toward neither the best nor the worst, and fully representing any regional differences due to energy use, material sourcing or other factors.

Chapter-5-

Result and Discussion

Study Area

The analysis of building materials were based on the quantity used assuming the house is a five story building. It is estimated for an average of 2,600 sq. ft. floor area, a five story building would produce approximately 5,128,640 MJ embodied energy and 412,254 kg CO_2. This has been calculated based on the quantity of materials required for construction as shown in Table 8. The estimated materials are converted into weight and then using the embodied energy and CO_2 emission for specific materials as given in Table 9, the total amount of embodied energy and CO_2 for the five story building is calculated-

Item	Description	Embodied Energy MJ	Embodied CO_2 Kg
1	Backfill (Using General Sand)	87,653	4,383
2	Flat Soaling (Using Common Bricks)	1,17,698	8,631
3	Cement Concrete Work Using General Cement	91,683	11,431
4	Brick Works Using Common Bricks	9,14,349	67,052
5	Tiles Work Using Ceramic Tiles	2,72,184	17,843
6	Plastering Work (Mortar Using General Cement)	2,27,296	33,249
7	Painting (Double Coat)	1,68,214	8,741
8	Door (Wooden + PVC)	11,24,227	39,181
9	Windows (Aluminium Framed)	8,75,200	44,640

10	Reinforced Concrete (Using General Cement)	12,50,138	1,77,103
Total		51,28,640	4,12,254

Embodied Energy and Embodied CO_2 for a five storey building using typical combination of construction materials in the study area

The materials for construction have a significant impact on the embodied energy and embodied CO_2 of a building. Another calculation has been made for the same five storied building using alternative combination of building materials (Table 9). In this calculation the materials are selected on the basis of their embodied energy, embodied CO_2 and availability. The analysis revealed that we can reduce approximately 52% of total embodied energy and 45% of total embodied CO_2 of a building only by using building materials with low embodied energy and low embodied CO_2. The principal materials for construction (cement concrete, mortar for plastering, reinforced concrete) in the study area are made from general cement (Type I cement as per Bangladesh Standard BDS EN197-1:2003). The study shows that there is a significant reduction in embodied energy and embodied CO_2 if the general cement is replaced with other cementitious materials like fly ash or blast furnace slag.

These types of cement (Type-II and Type-III as per Bangladesh standard BDS EN 197- 1:2003) are available in Bangladesh with similar physical and mechanical properties as type-I cement. By replacing type-I cement with type-II or type-III cement the embodied energy and embodied CO_2 can be reduced to 23% to 35% and 22% to 45% respectively. Therefore, selection of materials can significantly reduce embodied energy and CO_2 which play an important role in reducing the impact of climate change resulting from emission. The sustainable buildings should emphasis on use of recycled materials like bricks and concrete, natural ventilation using mixed mode design. Mixed mode design is a concept where mechanical and natural ventilations are provided for optimum comfort condition, which is 26 degree Celsius.

Conclusions:

1)The use of alternative building units like hollow concrete blocks for masonry construction reduces the energy consumption by 60% as compared to brick masonry.

2)The conventional RC roof or the Hourdi tile roof are energy intensive with embodied energy values of 548 MJ/m2 and 540 MJ/m2 respectively. The composite beam-panel roof is 13% energy efficient as compared to the RC roof.

3)A 50% and 25% energy saving may be achieved in roofs made of fibrocement channel units and brick vaults as relative to RC roofs and thus are the most energy efficient choices amongst the various alternatives considered.

4)The energy consumption in single storied buildings remains unchanged irrespective of the structural system adopted. However it is better to adopt a load bearing structure as it encourages decentralized products like bricks which supports the rural economy.

5)Materials like Cement, Steel and Bricks and Glass are the major contributors to the total energy consumption in RC buildings.

6)Buildings with lesser number of storey's are more energy efficient than multi- storied buildings.

7)Attempts in minimizing or replacing the conventional high energy materials like cement, steel, bricks with cheaper and local alternatives will lead to reduction in the embodied energy in buildings.

8)The cement industry is a large contributor to global CO2 emissions. CO2 is emitted from the calcinations process of limestone, from combustion of fuels in the kiln, and from power generation for purchased or self-generated electricity.

9)Estimated carbon emissions from cement production in 1994 were 307 MtC, 160 MtC from calcinations, and 147 MtC from energy use. These emissions account for 5% of 1994 global anthropogenic CO2 emissions.

10) Data collection for this effort is labor intensive, and we recommend that the emissions be reported in future years on a consistent basis. China accounts for by far the largest share of total emissions (33%), followed by the United States (6%), India (5%), Japan (5%), and Korea (4%). Overall, the top 10 cement-producing countries in 1994 accounted for 63% of global carbon emissions from cement production for that year. Regionally, after China, the largest emitting regions are Europe (12%), OECD-Pacific (9%), and Asian countries excluding China and India (9%), and the Middle East (8%).

11) This study was conducted to develop a model that could evaluate the CO2 emission in the construction phase of construction projects. Towards this end, the materials and equipment inputted in the construction methods used in the construction phase of construction projects were analyzed in the process of developing the model.

12) The CO2 emission of the materials was calculated using the I-O LCA approach, and an LCI database of construction materials was established by developing the corresponding equations.