CO_2 EMISSION REDUCTION OF CONSTRUCTION EQUIPMENT BY USING CLEANER TECHNOLOGY: CASE STUDY IN HIGH-RISE BUILDING CONSTUCTION

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การลดการปลดปล่อยก๊าซคาร์บอนไดออกไซด์จากเครื่องจักรกลในงานก่อสร้างอาคารสูง
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วิทยานิพนธ์นี้เป็นส่วนหนึ่งของการศึกษาตามหลักสูตรปริญญาวิศวกรรมศาสตรมหาบัณฑิต
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ธนิกุล แพทยานันท์ : การลดการปลดปล่อยก๊าซคาร์บอนไดออกไซด์จากเครื่องจักรกลในงานก่อสร้างอาคารสูง โดยใช้เทคโนโลยีสะอาด: กรณีศึกษาการก่อสร้างอาคารสูง (CO_2 EMISSION REDUCTION OF CONSTRUCTION EQUIPMENT BY USING CLEANER TECHNOLOGY: CASE STUDY IN HIGH-RISE BUILDING CONSTRUCTION), อ. ที่ปรึกษาวิทยานิพนธ์หลัก : รศ.ดร. ธเรศ ศรีสถิตย์, 152 หน้า.

ในปัจจุบันภาวะโลกร้อนนับเป็นปัญหาที่สำคัญและทวีความรุนแรงไปทั่วโลก ซึ่งประเทศไทยติดอยู่ในอันดับที่ 24 ของประเทศที่ ปลดปล่อยก๊าซ CO_2 ทำลายชั้นบรรยากาศโลก การก่อสร้างอาคารสูงนับว่าเป็นกิจกรรมหนึ่ง มีผลกระทบต่อสิ่งแวดล้อม ตั้งแต่ขั้นตอนเริ่มต้นการดำเนินโครงการจนกระทั่งโครงการเสร็จสมบูรณ์ เนื่องจากการก่อสร้างอาคารสูงเป็นกิจกรรมการก่อสร้างที่ใช้ความหลากหลายของเครื่องจักรและอุปกรณ์ ทั้งที่ใช้น้ำมันเชื้อเพลิงและ พลังงาน ไฟฟ้า ในการทำงาน จึงทำให้เกิดมลพิษทางอากาศโดยเฉพาะอย่างยิ่งการ ปลดปล่อย CO_2 งานวิจัยนี้มีวัตถุประสงค์ เพื่อศึกษาและประเมินปริมาณการปลดปล่อยก๊าซ CO_2 จากกิจกรรมการก่อสร้างอาคารสูง รวมไปถึง การลดการ ปลดปล่อยก๊าซ CO_2 ของเครื่องจักร ในงานก่อสร้างอาคารสูง และเสนอแนะ แนวทางการ ลดการ ปลด ปล่อยก๊าซ CO_2 โดยใช้เทคโนโลยีสะอาด (CT)

จากการศึกษาและสังเกตพบว่า งานก่อสร้างอาคารสูงประกอบไปด้วยกิจกรรมหลัก 3 กิจกรรม คือ งานโครงสร้าง งานสถาปัตยกรรม และงานระบบ โดยนำกิจกรรมทั้ง 3 งานนี้มาประมวลผลโดยคำนวณ หาปริมาณการใช้น้ำมันเชื้อเพลิงและไฟฟ้า ของเครื่องจักรกล หลังจากนั้นคำนวณหาปริมาณ ก๊าซ CO_2 ตามสูตรของ IPCC 2006 ผลการคำนวณช่วยสนับสนุนการเลือก วิธีที่เหมาะสมเพื่อลดการปล่อยก๊าซ CO_2 โดยใช้เทคโนโลยีสะอาด (CT) ที่พิจารณาจากวิธีการทั้งทางตรงและทางอ้อม

ผลการศึกษาพบว่า การก่อสร้างอาคารสูงของกรณีศึกษา ป ลดปล่อยก๊าซ CO_2 ทั้งหมด 1,295.34 ตัน-CO_2 หรือ 57.43 kg-CO_2/m^2 โดยกิจกรรม งานโครงสร้าง ปลด ปล่อยก๊าซ CO_2 625.87 ตัน-CO_2 เทียบเท่ากับ 48.32 % ของกิจกรรมทั้งหมด กิจกรรมงานสถาปัตยกรรม ปลดปล่อยก๊าซ CO_2 373.14 ตัน-CO_2 เทียบเท่ากับ 28.81% ของกิจกรรมทั้งหมด และ 296.33 ตัน-CO_2 จาก งาน ระบบ เทียบเท่ากับ 22.88% ของกิจกรรมทั้งหมด หลังจากนั้น นำผลมาประยุกต์ใช้ กับเทคโนโลยีสะอาด โดยแยกเป็น วิธีการทางตรงและวิธีการทางอ้อม ซึ่งผลคือ เทคโนโลยีสะอาดสามารถลดก๊าซ CO_2 ทั้งโครงการลงมาเหลือ 1,038.64 ตัน-CO_2 หรือ 46.05 kg-CO_2/m^2 ลดการปลด ปล่อยก๊าซ CO_2 ที่เกิดจากงานโครงสร้าง ลงได้ 156.91 ตัน-CO_2เทียบเท่ากับ 12.11 % ของกิจกรรม ก่อนการลด ทั้งหมด งานสถาปัตยกรรม ลดลง 50.87 ตัน-CO_2 เทียบเท่ากับ 3.93% ของกิจกรรม ก่อนการลดทั้งหมด และ 48.91 ตัน-CO_2จากงานระบบที่ลดลงเทียบเท่ากับ 3.78 % ของกิจกรรม ก่อนการลด ทั้งหมด ดังนั้น เทคโนโลยีสะอาดสามารถ นำมาใช้ ลดการปล่อยก๊าซ CO_2 จากโครงการงานก่อสร้างอาคารสูง

ภาควิชา วิศวกรรมโยธา	ลายมือชื่อนักศึกษา...................................... ....
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THANIKUN PADTHAYANAN: CO_2 EMISSION REDUCTION OF CONSTRUCTION EQUIPMENT BY USING CLEANER TECHNOLOGY: CASE STUDY IN HIGH-RISE BUILDING CONSTRUCTION. ADVISOR: ASSOC. PROF. THARES SRISATIT, Ph.D., 152 pp.

The high-rise building construction has an important role on environment since the beginning to completion of the project as the construction activities utilize type of machines and equipments, particularly the heavy ones. Such machines and equipments consume a significant amount of fuel oil and electricity that emits large quantity of air pollution, especially CO_2 emission leading to global warming which is a major concern worldwide. This research presents a case study of CO_2 emissions reduction of construction equipments in high-rise building construction by applying Cleaner Technology. The research separated three main sources of CO_2 emission which are: Structural Activities, Architectural Activities and System Activities. After that the research used surveying method for collected the data such as the quantity of equipments in each activities and time operated. The data is estimated by the fuel oil consumption and electricity by following IPCC Guideline 2006 and evaluation of carbon footprint products by Carbon Footprint Committee. The results show that the CO_2 emission of overall construction site was 1,295.34 ton-CO_2 or 57.43 kg-CO_2/m^2. CO_2 emission released from the Structure Activities was 625.87 ton CO_2 equivalent to 48.32% CO_2 of all activities, 373.14 ton-CO_2 from Architectural Activities equivalent to 28.81% CO_2 of all activities, and 296.33 ton CO_2 from System Activities equivalent to 22.88% CO_2 of all activities. Regarding the CT application, reduction of CO_2 emission is studied by considering direct and indirect methods. The direct method could display the explicit results; stopping the engine of equipment every time whenever the equipment are not used, maintenance of equipment by follow the preventive program of company, changing the size of concrete truck. Indirect method gave the uncertain results depending on many factors such as changing the employee's behaviors, planning for evident work procedures and using the proper equipments with the manner and the right skill of works. Therefore, Cleaner Technology can reduce CO_2 emission from this project from 1,295.34 ton-CO_2 to 1,038.64 ton-CO_2 or 19.82 % reduction.

Department : Civil Engineering Student's Signature ....

Field of Study : Infrastructure in Civil Engineering Advisor's Signature ....

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CHAPTER I

INTRODUCTION

Nowadays, building construction business is gaining popularity with rapid growth in developing countries that causes from many factors such as rapid economic growth and especially rapid population growth in the limited area. The buildings construction has an important role on the environment because of the process of building construction since the project begins until the completion of the project uses the machines and equipments which are consumed oil fuel and electricity that causes air pollution especially carbon dioxide emissions. Carbon dioxide gas causes of the greenhouse effect or global warming that a major problem around the world.

Many kind of equipment are used in high-rise building construction which plays a role in the construction project from beginning stage to finished stage of the construction project, therefore, carbon dioxide emissions occurs at any time of construction. Cleaner Technology can be used to reduce the carbon dioxide emissions at source with no treatment and no solve the problem at the end of the project such as what the equipment release carbon dioxide gas, what kind of work that occur the carbon dioxide emission included evaluate the process of construction. After that, applying the Cleaner Technology to suggest and improve for reducing the amount of carbon dioxide emissions from the construction project.

Moreover, many countries have much concerned to environment by identifying methods to reduce carbon dioxide emissions caused by several of sources in different methods such as use an application of economics to attract people to focus on reducing carbon dioxide emissions. Cleaner Technology can be applied with building construction by reducing carbon dioxide emissions and benefit to the owners in reducing investment cost of fuel consumption that called design for mutually beneficial (Srisatit T., 2007.).

For this research, selecting the high-rise building because high-rise building construction not only used a lot of construction equipments that emitted carbon dioxide gas but also consumed a lot of energy in construction activities. The construction activities took a long time to complete the project. Moreover, land price in Bangkok increasing with limitation area lead the property owners developing the high-rise building to fulfill their benefits.

1.1 Objectives of Study

1. To estimate the amount of carbon dioxide emissions from construction activities of high-rise building.

2. To select the methods to reduce the carbon dioxide emission by using Cleaner Technology (CT).

1.2 Scopes of Study

1. Study details and processes of high-rise building construction and review literature, books and concerning with construction methods

2. Study during phase time of high-rise building construction project in each process by using data collection that through the construction almost completely.

3. Study the various types of construction equipments and fuel consumption over a period of time in construction.

4. Collect and revise the data available from construction report by focusing on the working time and engine consumption of equipment in each construction system.

5. Identify the amount of oil fuel and electrical energy as a source by using estimation from the data collection in each task of high-rise building construction.

6. Estimate carbon dioxide emissions in building construction causes of construction equipment by using Intergovernmental Panel on Climate Change or IPCC Guideline Version.2006.

7. Simulate the application of Cleaner Technology to reduce amount of carbon dioxide emission from significant process of building construction and equipments.

8. In such case of Labors and material transport work in Structural Activities, means included the transported manpower with some or small equipment and material of all activities (Structural, Architectural and System Activities) by using only site elevator.

1.3 Expected Output of Study

1. Quantify the carbon dioxide emission rate in kilogram-CO_2 per m^2 unit of high-rise building construction project.

2. Reducing carbon dioxide emission from construction activities that cause global warming today.

3. Suggestion Cleaner Technology concept that could reduce carbon dioxide emission in the construction project.

1.4 Assumption of Study

1. Some equipment is used in construction which is small sizes or average fuel consumption and less than will not include because carbon dioxide emission causes very rare occurrence. It can be omitted because it is not significant enough to consider.

2. Identification the source of carbon dioxide emission all of construction process but excluded some architecture work such as decoration, interior and landscape of building because it is over the scoping of engineering.

3. High-rise building in this study means the residents building includes condominium and the qualification of building with the middle price. (40,000 – 80,000 Bath/ m^2) during 2008-2012 sale.

4. When simulated Cleaner Technology in each process of building construction, the construction phase time will not decreasing or increasing to whole the project time and not effect on quality of works. Only reduce the working time of construction equipment in hour's unit per day.

5. The transportation of the Tower crane structure will not be calculated in System Activities

CHAPTER II

LITERATURE REVIEWS

The high-rise building is generally considered as one that is taller than the maximum height which people are willing to walk up; it thus requires mechanical vertical transportation. This includes a rather limited range of building uses, primarily residential apartments, hotel, and office building, though occasionally including retail and educational facilities.

2.1 High-Rise Building:

The Emporis Standards Committee, (2009) defines a high-rise building as "a multi-storey structure between 35–100 meters tall, or a building of unknown height from 12–39 floors".

A high-rise building is distinguished from other tall man-made structures by the following guidelines:

1) It must be divided into multiple levels of at least 2 meters height;

2) If it has fewer than 12 such internal levels, then the highest undivided portion must not exceed 50% of the total height;

3) Indistinct divisions of level such as stairways shall not be considered floors for purposes of eligibility in this definition.

2.2 Construction Activities:

Generally, construction activities consist of 3 main activities:

2.2.1 Structural Activities consists of 5 sub-activities

Figure 2.1: Structural Activities in construction project

2.2.1.1 Site Planning and Investigation

For site planning, tasks should be divided into smaller independent executable subtasks. The more time and recourses allocated for planning at each process of planning, the greater opportunity to develop optimal solutions rather than something that is good enough (Peurifoy, 2006).

For site investigation, is usually done in two stages: (1) a surface evaluation of the building site (2) a subsurface investigation. The surface evaluation of the site normally consists of a topographic survey to establish grades for drainage, landscaping requirements, and the placement of services. In addition, the survey information gathered at this time can be used by the contractor to estimate fill and excavation quantities. Subsurface investigation consists of the evaluation of the soil below the surface to establish criteria for the foundation requirements of the proposed structure. The depth at which this bearing available will dictate type and cost of the foundation. If the project is feasible from soil capacity, then investigation will help to estimate the cost and will influence the design of the foundation

2.2.1.2 Piling Work

Piling work is used to support the load of the building to safe a location. This is important first to determine the quality of materials used and controlled with high accuracy. If there are errors in the piling work then will affect to the building failure may cause cracking or failure loss due to subsidence.

2.2.1.3 Excavation Work

Excavation work depended on the type of soil at the site and will be the major factor in determining the type of excavating equipment needed for the job. If the soil is loose or non cohesive, excavating can usually be started with clamshell bucket and completed with pay loader, a shovel mounted on a tractor, or it may be done completely by pay loader or bulldozer. More cohesive soils require more power; in such case, a power shovel or pull shovel (backhoe) will be required. If the soils that are too soft or wet to support equipment traveling over them may be excavated by dragline.

2.2.1.4 Foundation Work

The foundation of a building is generally divided that part of the structure transmits the superimposed load of the building to the supporting soil. The foundation must be proportioned to ensure that the superimposed building loads do not exceed the load-bearing capacity of the soil and the differential settlements are kept to minimum.

The type of foundation used in any particular case depends on the size and building loads, the depth from the ground surface to the stable layer of the bearing material, and the location of the structure with respect to other buildings

For large building, it is not uncommon for portions of their foundations to extend to bedrock to develop adequate support for the imposed loads. This type of foundation can be termed a deep foundation and is accomplished through the use of piles, caissons, deep wall foundation, mats, and in some case, a combination of mats and piles.

2.2.1.5 Superstructure Work

1) Scaffolding Work

Scaffolding is an impermanent framed support arrangement consisting of wood boards and tubes made from metal. They are constructed for the purpose of providing an above-ground support for workers who are working on buildings.

Scaffolding generally used at household building sites are made of wooden platforms, known as battens, shorter metal tubes referred to as transoms, vertical metal tubes referred to as standards, and horizontal metal tubes referred to as ledgers. Standards, the vertical metal tubes, are joined to ledgers, and the transoms are joined to wooden battens at a right angle for greater support. However, to provide greater durability, diagonal braces are also used. Typically, clips for scaffolding are also applied to combine and keep the scaffolding structure together. Additionally, when constructing scaffolding, netting and/or guard rails may be used for extra security.

However, the person who builds scaffolding himself must be certain that he can construct a safe and secure structure to prevent unnecessary dangers and risks. If the scaffolding is hazardously constructed, people could get harmed by either falling off the scaffolding structure or bystanders could get struck by scaffolding should it fall. Those in danger of potential harm include not only yourself, but workers and anyone who is around the work site. An unnecessary insurance claim or even lawsuit could be the outcome. Scaffolding may not be necessary if only a single story is being added. However, it is best to consult with a builder to be sure of what your needs are. Many builders would recommend the use of appropriate scaffolding for two-story and higher constructions.

2) Wooden Structural Work

Wooden structural work used to support the building while the building is still not stable enough to support the load of the concrete from the beginning. Its main function is used for bracing, temporary setting spot for constructed a building structure, the material used depends on the height, loading, and speed of work. Control the use properly materials, size and correctly installation.

3) Concrete Work

3.1) Pre-Concrete Placing Work

Before placing concrete, the sub grade must be properly prepared, and forms and reinforcing must be erected according to specification. Subgrades must be trimmed to specific evaluation and thoroughly compacted and should be moist when the concrete is placed. Forms must be made of material that will impart the desired texture to the concrete and should be clean, tight, and well braced. They must be oiled or treated with some type of form seal that will prevent them from absorbing water from the concrete.

Preparation must also include the building of adequate runways for wheelbarrows or buggies. Build runways to be reasonably smooth and rigid enough to prevent the wheelbarrows or buggies from bouncing or jarring as they travel. Some means of transferring concrete from the wheelbarrow, buggy, or bucket into the forms must also be provides (Andres and Smith, 2001).

3.2) Concrete Placing Work

When concrete has been transported to the site, it is conveyed by a variety of methods, including belt conveyors, buckets, shoots, cranes, pumps, wheelbarrows, and other equipment. Concrete should be conveyed in such a manner that it is not allowed to dry out; it should not be delayed, and it should not be allowed to segregate before it is placed.

Concrete should be deposited continuously as near as possible to its final position. Concrete should be placed in horizontal layers of uniform thickness, each layer being thoroughly consolidation before the next is placed. The rate of placement should be rapid enough that a layer of concrete is not yet set when a new layer is placed upon it. Drop shoots should be used to prevent segregation and spattering of mortar on reinforcement and forms in wall placements (Nawy, 2008).

Andres and Smith, (2001) Concrete must be placed as nearly as possible in its final position. It should not be placed in large quantities in one position and allowed to flow or be worked over long distance in the form. The mortar will tend to flow and ahead of the coarser materials, thus causing stone pockets and sloping work planes.

When concrete is placed on a sloping surface, placing should begin at the bottom of the slop. This system will not only improve the compaction of the concrete as placing progresses but will prevent the flowing out of mortar, which would occur if pouring had begun at the top of the slope.

Placing of concrete for a slab must begin against a wall or against previously placed concrete. Dumping away from previously placed concrete allows the coarse aggregate to separate from the mortar. Concrete should be placed in wall forms in relatively thin layers or lifts, 12 to 18 in. deep, each layer placed the full length of the form before the next lift is began. In addition, the first batches of each lift must be placed at the ends of the form section or in corners, and placing should proceed toward the center. This positioning is done to prevent the trapping of water at ends of the sections, in corners, and along form faces.

4) Post-Tension Slab Work

Post-tensioned floors are frequently used today, particularly in high-rise buildings. The primary advantage of post-tensioning are the ability to use thinner slabs, the crack control derived from the presence of a significant pre-compression force in the concrete, greater shear capacity as a result of the pre-compression force, and greater deflection control as a function of reverse cambering.

A feature of great importance is the short stripping times that can be achieved with post-tensioned slabs. The minimum period between concreting and stripping of formwork is 48 to 72 hours, depending upon concrete quality and properly temperature. When the required concrete strength is reached, the full pre-stressing force can usually be applied and the formwork stripped immediately afterwards. Depending upon the total size, the construction of the slabs is carried out in a number of sections. The weight of a newly concreted slab must be transmitted through the formwork to slabs beneath it. Since this weight is usually less than that of a corresponding reinforce concrete slab, the cost of the supporting structure is also less.

5) Concrete Road Construction Work

Cement concrete uses cement and water as the binding agent for the aggregate mix. Concrete paving also requires thick base layers of compacted aggregate to form a solid surface for the road. Workers must then construct forms, or molds, along the edges of the planned road to prevent the concrete from spreading before it sets. Cement concrete is broken up with regular joints, connected by wire baskets and dowels. This allows the concrete to expand and contract during seasonal temperature changes without cracking the surface of the road. The surface may be tined, or grooved, with a machine for better traction.

2.2.2 System Activities consists of 8 sub-activities

Figure 2.2: System Activities in construction project

2.2.2.1 Piping System

Piping systems are classified as follows:

1) Service provided. Heating, cooling, etc.

2) Medium conveyed. Steam, hot water, chilled water, refrigerant, oil, gas, condensate, chemicals, etc.

3) Pressure class. Low-, medium-, or high-pressure classes. The pressure ranges very with the types of media to be conveyed, such as steam, water, etc.

4) Temperature class. Low-, medium-, or high temperature classes. The temperature ranges vary with types of media to be conveyed.

5) Piping arrangement. One-pipe (monoflow) or two-pipe system, direct or reverse return, series or parallel flow, etc.

6) Hydraulics. Gravity or forced flow, open or closed.

7) Piping materials. Steel, copper, plastic, non-metallic, etc.

Most piping systems use pumps or compressors to maintain the flow of the fluid. This is called a *forced systems*, however, pumps are not always required. Steam flows in a piping system because of the pressure differential between the steam source and the devices that use the steam. Steam condensate flows by gravity or, if adequately cooled,can be pumped.

Piping for fluid systems is analogous to ducts for air systems. Both serve to transport energy from equipment to equipment. Piping includes pipes, fittings, and accessories, which differ with the type of fluid, services, and application. Many fittings and accessories are required to make a complete operational piping system. Some are used in all systems, while others are applicable only to a particular system.

2.2.2.2 Plumbing System

Water demand for plumbing facilities depends on the number and type of fixtures actually installed. In practicle, the actual number of plumbing fixtures in modern buildings usually exceeds the minimum required by codes, particularly in public assembly facilities and high-rise office buildings.

1). Food Services

Water demand for food services varies considerably between residential and commercial equipment. In general, food preparation and cooking do not require much water. The major demand for water is for washing in sinks or dishwashers. The use of water for washing in skins has been accounted for in the plumbing fixture units.

2). Laundry Services

Water demand for laundry also varies between residential and commercial equipment. Residential clothes washers require 20 to 40 gal for water per wash, depending on the size of the machine and design of the wash cycle.

3). Exteriors

Water usage for building exteriors depends on the size of the lot and the portion that is landscaped. In some luxury residences, campus-type institutions, or country clubs, water demand for irrigation could be far greater that the usage within buildings.

4). Swimming Pools

Swimming pools vary widely in side, from residential pools containing a few thousand gallons of water to Olympic-size pools containing several hundred thousand gallons. Normally, the flow rate of the circulating pump is designed to turn over (circulate) the entire volume of water in the pool in 6 to 8 houses, or 3 to 4 times in 24 hours. About 1 or 2 percent of the pumped circulation rate should be provided as continuous makeup water demand to overcome losses from evaporation, bleed-off, and spillage.

2.2.2.3 Hot-Water System

A hot-water system is a subsystem of the domestic water system. The use of hot water in buildings varies considerably, from very little in office-type buildings to night in residences, restaurants, and hotels. Hot water is normally generated in the building by the installation of water heaters using oil, gas, steam, or electricity as an energy source. In general, water heaters have a storage capacity of from several gallons to hundreds of gallons. It is more economical to preheat water in storage than to generate hot water on demand. Furthermore, storing hot water make it easier to maintain an even water temperature.

Plumbing facilities for buildings are primarily toilets, bathrooms, and washrooms. The requirements for such facilities are normally analyzed and planned by the architect to fulfill the needs of the building's occupants; however, planner facilities must equal or exceed the minimum code requirements. In practice, the plumbing facilities in high-quality buildings are more than are required by the code, for the following reason:

1) To improve convenience facilities and frequently duplicated, so that occupants need not travel too far on one floor or to other floor to use them.

2) To accommodate the fluctuation in a building's occupants the proportion of a building's occupants of each sect may changes over time; thus, extra facilities must be built in to accommodate this fluctuation. This is particularly true for assembly and sports facilities, where different events may draw a different mix of participants.

3) To blocked congestion the use of a building's plumbing facilities is usually concentrated at certain time of the day. To avoid congestion, extra plumbing fixtures beyond the number specified as a minimum by that code should be provided.

2.2.2.4 Sanitary System

Drainage in building consists of three major components: sanitary waste, storm water, and specialty waste, such as toxic, radioactive, chemical, or other processing wastes. Sanitary waste and storm water may be piped separately or combined, depending on the public sewer system to which the drainage is connected. Combined storm and sanitary sewer systems still exist in some major cities, carried over from the early practice of discharging untreated sewage into rivers.

A sanitary drainage system is thus a drainage system designed to carry away sanitary wastes (including soil wastes) from within a building to a public sewer or to a sewage disposal plant. The system may be designed to flow by gravity without mechanically or electrically powered equipment or it may be designed to flow under pressure by pumping. The gravity system is, of course, more reliable and more economical to operate and thus should be used whenever feasible. The discussion in this section will deal with gravity flow only.

1) Sewage Treatment System

To protect water resources and the greater environment, all waste from buildings and industrial processes be treated to meet certain standards of quality. Domestic sewage from dwellings and drainage-waste-venting system in buildings are permitted to be discharged into the public sewer system, which provides the necessary treatment prior to its discharge into nature. When public sewers are not accessible, or when there is no public sewer system in the vicinity of a building or buildings, a private sewage treatment system will have to be constructed.

The sewage treatment process may be divided into three major steps:

1.1) Primary treatment, which is sub-divide into:

1.1.1. *Sedimentation and retention* raw sewage is retained for the preliminary separation of indigestible solids and the start of aerobic action

1.1.2. *Aeration* Introduction of air through natural convection or mechanical bowers to accelerate the decomposition of organic matter

1.1.3. *Skimming* Removal of scum that floats on top of the partially treated sewage

1.1.4. *Sludge removal* Disposal of heavy sludge at the bottom of treated sewage

1.2) Secondary treatment, the removal of fine suspended matter from the effluent through a filtration process, such as the use of sand filters, drain fields, or seepage pits.

1.3) Tertiary treatment, the disinfection of effluent by the addition of chemicals, such as chlorine.

2) Water Pump

Water pressure required for water distribution is determined from a number of design parameters: water demand routing, type of fittings, accessories, etc. All these factors contribute to pressure loss. If the water supply does not have sufficient pressure to overcome the total pressure loss, that the pressure must be boosted by a pump; however, a pump consumes energy and requires maintenance; thus, it should be avoided whenever possible. Plumbing fixtures are receptacles, devices, or appliances that are supplied with water or that receive liquid-borne wasters and then discharge waster into the drainage system. The following are some plumbing fixtures commonly used for building services, whit their common abbreviation in diagrams:

2.1) Water closets (WC)

2.2) Sinks (SK)

2.3) Bidets (BD)

2.4) Urinals (UR)

2.5) Bathtubs (BT)

2.6) Service sinks (SS)

2.7) Kitchen sinks (KS)

2.8) Lavatories (Lav or LV)

3) Drainage-Waste Venting

When the sanitary drainage system is connected to a public sewer, the entry of sewer gas, insects, or rodents through the system must be avoided. To overcome this problem, all drainage equipment (including all plumbing fixtures) connected to the sanitary drainage system must be separated by a liquid seal that acts to separate the building from the sewer. Each trap must be adequately vented to the atmosphere to prevent the liquid sale from being siphoned or sucked dry if a pressure differential is created between the building and the sewer owing to the flow of the flow of the drainage.

2.2.2.5 Air Conditioning System

1) Air Handing Unit

The air-handling system consists of one or more fan section, heat-exchange sections foe heating and / or cooling, an air filtration section, a section for mixing return air with outside air, and a discharge air plenum. A small air-handling unit may simply contain a supply air fan and coils. A large air-handling unit up to 100,000 to 300,000 cfm may be custom-built to contain an array of components. The following components can be found in air-handling unit:

1.1) Fan section, for supply air return air / relied air fans

1.2) Cooling section, for hot-water or refrigerant cooling coils

1.3) Heating section, for hot-water or steam coil, a gas heat exchanger, or an electrical coil

1.4) Humidification section for extra humidity, if required

1.5) Filter section, for prefiltering, filtering, and post-filtering

1.6) Air-mining section, outdoor air to mix with recirculating air

1.7) Discharge air plenum

1.8) Other components, for electrical power, controls, operating a motor, drainage, etc.

Depending on their size, air-handling unit can be delivered as a single package or assembled from modular components. Custom applications may even be built on the job site from panels or sheet metal applied to a metal frame.

2) Ductwork System

Ductwork is part of the air-handling system and includes the supply, return, outside air, relief air, and exhaust air ducts. Whereas the supply and return air ducts must be connected to the air-handling units, the other ducts may be run independently. Ducts are usually fabricated from sheet metal, such as galvanized steel, aluminum, or stainless steel; thus ductwork is also called *sheet metal work,* although some ducts are made with nonmetals, such as plastics.

Duct installations are most economical when maximum use is made of straight duct runs, and the number of fittings is minimized. Design of fittings is important to reduce pressure requirements. Elbow fitting should have turning vanes. Butt-head tee fittings should be avoided. Branch ducts in higher-velocity duct systems should be connected to the main duct using factory-made aerodynamically designed fittings.

2.2.2.6 Drainage System

The rainwater conveys from some point to the other points by passed a storm drainage system as roofs, patios, and areaways of buildings and parking lots, and roadways, lawn, and gardens on the site. In general, except for small or incidental areas, all exterior storm drainage should be connected externally to the building storm drainage system.

2.2.2.7 Electrical System

Most large buildings contain loads with diversified characteristics, such as single-phase lighting and appliances and three-phase motors. Thus it is quite common to have more than one power distribution system in the same building, although multiple systems are costly and difficult to maintain. Cost-benefit studies should be made to compare option. As a rule, if more than one system is necessary, the main system should be selected to satisfy the predominant loads, with one or more subsystems converted from the main system for the minor load.

1) Transformer

Transformers are power transmission equipment primarily intended to convert a system's voltage from one level to another. All transformers operate on the principle of magnetic induction: Primary and secondary coils are wound on a common and the outgoing side the secondary. If the voltage is increased from primary to secondary, the transformer is a *step-up* transformer; if the voltage is decreased, the transformer is a *step-down* transformer. With magnetic induction, voltage is induced from the primary to the secondary.

2) Main Switchboards

A switchboard is an assembly of switches and circuit protection devices from which power is distributed. The switchboard serves as the main distribution center of a small system or as portion of the distribution center of a large system.

3) Wire Ways

Wire ways are used to enclose a large number of wires. They are usually 3 in. to 8 in size, contain tens or hundreds of wires, and should be installed where they are accessible. Surface metal raceways, such as “wiremold” and “plugmold” are examples of smaller wire ways.

The installation of wires (or cables) in raceways is strictly regulated. Generally, no more that 40 percent of the cross-sectional area of the limitation is necessary for toy key reasons:

3.1) To prevent excessive heat buildup All wires have resistances and impedances that create a power loss which turns into heat and, if unabated. May cause the breakdown of the insulation material or even a fire.

3.2) To permit the physical installation of the wires in conduits must be pulled into the conduits by special tools. A clear space must be provided for the wires to be pulled in easily, without damage.

4) Lighting

Lighting design is usually the coordinated effort of the architect, interior designer, lighting designer, and electrical engineer. Lighting accounts for one of the larger electrical loads in most building. In general, lighting fixtures and designed for 120-V, single-phase power; however, they may also be designed for use on 208-240-, and 277-V, single-phase power systems.

A continuous improvement in light-source technology has increased the efficiency of converting electrical energy to lighting energy, which in turn has reduced the need for electrical power for lighting in buildings.

5) Grounding

In general, all building electrical systems are intentionally grounded at the point where the voltage to ground is the lowest. There are several reasons for grounding:

5.1) Grounding protects the system and equipment from overvoltage due to accidental contact with higher-voltages sources, such as the primary voltage side of the distribution system, which may exceed several hundred thousand volts.

5.2) When lightning strikes a building and its electrical system, the electrical wiring and insulation on equipment may break down, and lightning current will flash over to seek the ground. If the system is properly grounded, the lightning will follow a direct path to the ground, by passing the feeders and equipment.

5.3) Grounding protects people from heavy electrical shock. If the system and equipment are grounded and the electrical circuit is a accidentally shorted to the equipment, the circuit protection device should trip and cut off the circuit. If the system is not grounded, then any accidental grounding of the wire through the equipment may pass through a person who happens to be touching the equipment.

5.4) A grounded system is more economical than an ungrounded one. The grounded side of a circuit must not be switched. Thus a single-pole switch is required, whereas a double-people switch must be used on an ungrounded single-phase system.

6) Emergency Power

Emergency power systems are required by building code to ensure the continuity of a building when a loss of normal power may create a hazard to life, a fire hazard, or a loss of property or business.

The capacity of essential loads (emergency and critical) varies with the design and occupancy of a building. Obviously, a single-story office building does not require anywhere near the essential load of a high-rise building, a hospital, a laboratory, or a special industrial plant. In general, the essential load for offices may range from 10 percent to 20 percent of the total connected load and may even be as high as 40 percent for super-high-rise buildings or hospitals.

2.2.2.8 Telephone System

Telephone services are usually provided by public utilities, which may be owned by private enterprise. With the exponential development of new telephone technology, such as cellular technology, such as cellular telephone systems, private branch exchanges (PBX), wireless telephones, pagers, Voice over Internet Protocol (VoIP), and facsimile (FAX or fax), the planning of telephone system in a building has become more complex. Often, the advice of the public utility or an independent telecommunication consultant is necessary if a new facility is to have state-of-the-art capabilities.

Wiring for telephone systems need not be installed in raceways; however, for security and aesthetic reasons, all wiring within finished spaces should be concealed.

Receptacles should be provided within the telephone closets for equipment. Telephone trunk lines should be terminated in telephone panels or in telephone closets for splicing and distribution.

2.2.2.9 Fire Alarm System

Fire and smoke detection devices should be located where there is a likely hazard, such as in storage rooms, electrical-mechanical rooms, and public egress areas (e.g., in entrances, elevators, or lobbies, near stairways). The fire command center where the control panel or the command console is located, should be in a secure locale, constructed of fire walls, preferably, with a direct means of egress.

Visual annunciating devices, such as flashing or strobe lights, should be provided for the hearing-impaired, following ADA requirements. In addition, when a number of strobes are within a field of view, synchronization of the strobes offers an easy solution for complying with ADA requirements concerning photosensitive epilepsy.

The fire alarm system should be coordinated with the building HVAC control system so that the HVAC system may operate in a manner that assists in the safe and speedy evacuation of the building's occupants. This is usually achieved through the efforts of the HVAC design engineer, who attempts to sequence the quantities of supply, return, exhaust, and outside air to maintain a smoke-free environment at the building exit ways. In designing the fire alarm system, the designer should study the feasibility and economics of establishing an integrated fire alarm and building management system that is most appropriate for the building.

2.2.3 Architectural Activities consists of 7 sub-activities

Figure 2.3: Architectural Activities in construction project

2.2.3.1 Masonry Work

Building with masonry involves two types, the exterior walls are built first and the remainder of the building is framed into them in such a way that those walls transmit the loads of the building directly to the foundations. They are called bearing wall. In the other type, the load-bearing framework of a building is constructed of steel, concrete, or timber, and masonry may be utilized to close the building; the walls are simply curtain wall.

For curtain wall, the modern certain wall must be capable of more than the ability to resist moisture penetration. To meet present day energy-efficiency requirements, insulation values and control of air leakage are concerns that must be addressed when selecting materials and establishing details for the design of the curtain wall. This also must be accomplished inexpensively and without compromising the aesthetic value of the building.

The method and materials used in curtain wall design and construction vary depending on the type of building and the amount of money available. From a construction point of view, curtain walls provide the following advantages over traditional construction:

1) The reduction in the exterior wall thickness results in more floor space.

2) Because the curtain wall must support only its dead weight, it needs to be designed for wind loads only, which results in a lighter wall section. In high-rise structures, the saving can be achieved through smaller foundations and supporting beams

3) The application of the curtain wall can be coordinated with the construction of the structural frame, which results in shorter construction times.

4) Because curtain walls usually come in prefabricated panels, they can be well insulated and sealed which prevents excessive air and moisture leakage.

2.2.3.2 Plastering Work

Plaster is well known and widely used for finishing walls and ceiling in many types of building. Either Portland cement or gypsum plaster may be used, depending on the composition of the wall and the conditions to which the surface will be subjected. Portland cement plaster may be applied to concrete, masonry, and metal lath bases and is used where walls, ceiling, and partitions are subject to rough use or extreme moisture condition. Gypsum plaster bonds well to gypsum lath, metal lath, fiberboard lath, and gypsum or clay tile, or scratch, coat; the second, or brown, coat; and the finish coat.

2.2.3.3 Tile, Floor and Terrazzo Covering Work

1) Floors have a lot to do with our visual and tactile appreciation of a building. Floors are also a major functional component of a building. They are its primary wearing surface, subject to water, grit, dust, and the abrasive and penetrating actions of feet and furniture. They require more cleaning and maintenance effort than any other component of a building.

Floor structures are frequently used for the distribution of electrical and communications wiring, especially in floor areas that are broad and have few fixed partitions. If the needs for electrical and telephone services are minimal and predictable, the most economical horizontal distribution system for wiring in a floor consists of conventional conduits of a metal tubing that are embedded in the floor slab or concrete topping. In most commercial buildings, there are several alternative systems for creating this flexibility.

2) Most of commercial buildings used a ceramic tiles because smaller than quarry tiles are referred to collectively. Ceramic tiles are usually glazed. The most common shape is square, but rectangular, hexagons, circles, and more elaborate shapes are also available. The smaller sizes of tile are shipped from the factory with their faces adhered to large baking sheets of plastic mesh or perforated paper.

3) Terrazzo is exceptionally durable flooring. It is made by grinding and polishing a concrete that consists of marble or granite chips selected for and color in a matrix of colored Portland cement or other binding agent. Terrazzo is installed over thin bed of sand that isolates it from the structural floor slabs, thus protecting it to some extent from movements in the building frame (Allen and Lano, 2004).

2.2.3.4 Ceiling Work (Andres and Smith, 2001) The type of ceiling to be used will depend on a number of factors, including the type of structural floor in the building, the location of the mechanical services, the intended use of the building, and whether acoustical treatment is required. When the building's mechanical services are located below the floor slabs, they will have to be hidden by suspending the ceiling below them. Heavy wires or small rods attached to the underside of the floor slab support a system of T-bars.

In some applications, the space above the ceiling becomes part of the heating and ventilation system and is used for the distribution of air throughout the building space. Prepainted ribbed sheet metal panels can serve as grilles to distribution the air uniformly and provide an interesting, durable, and noncombustible ceiling finish.

2.2.3.5 Concrete Stairs Work

Reinforced concrete stairs may be precast or cast in place. Precast units must be tied into the structure, which may be done by casting the topping slab around the lower end. Anchor plates cast into the end of the stair may be welded to a matching plate in the lower floor. The top end of the stair usually rests on a beam ledge.

A stair to be cast between existing walls requires a soffit form and riser forms held in place by inverted stringers. The stringers must be supported independently of the soffit form, and this may be done by wedging across the stair, from one stringer to the other.

2.2.3.6 Thermal Insulation Work

Insulation may be applied directly to the underside of floors, or a suspended ceiling system may be employed. In either case, many kinds of insulation may be used, including insulating boards, rigid slabs, or sprayed-on insulation consisting of vermiculite plaster or cellulose.

When insulation is to be applied under concrete floors, nailing strips should be cast into the bottom of the slab on appropriate centers for the type of insulation being used. The surface must be primed, and the first layer of insulation is applied at right angles to the nailing strips, using hot asphalt or an approved adhesive on the contact face and edges. This layer is further secured with nails and washers. The second layer is then applied at right angles to the first, using the appropriate adhesive.

2.3 Construction Equipments

Every piece of construction equipment is designed to deal with material in one form or another. Raw material of the earth may be broken up, dug out, or sucked in from its natural location. In that move the material properties will be changed from a natural state to a new one caused by the equipment. Other construction equipment is designed to handle loose or flowing material-to weight, proportion, or mix it for use in a more finished product of construction. This is an important part of processing some construction materials. They will be finished by molding, vibrating, and compacting them with the use of specially designed equipment. Still other materials for construction will be ready-made or manufactured in designed pieces. These will be handled by another type of construction equipment.

2.3.1 Excavators

Hydraulic excavators may be either crawler or pneumatic-tire-carrier-mounted, and many different specialized attachments are available for individual job applications. With the options in types, attachments, and sizes of machines, there are machines for almost any application, but each offers variation in economical advantage. Hydraulic power is the key to the advantages offered by these machines as shown in Figure 2.4.

Figure 2.4: Excavator in construction site project.

The hydraulic control of machine components provides

a) Faster cycle times.

b) Positive control of attachments.

c) Precise control of attachments.

d) High overall efficiency.

e) Smoothness and ease of operation.

Hoes are used primarily to excavate below the natural surface of the ground on which the machine rests. A hoe is sometimes referred to by other names, such as backhoe or back shovel. Hoes are adept at excavating trenches and pits for basements, and the smaller machines can handle general grading work. Because of their positive bucket control, they are superior to draglines in operating on close-range work and loading into haul units.

Wheel-mounted hydraulic hoes are available with buckets up to 1.5 cubic-yards. Maximum digging depth for the large machines is about 25 ft. with all four outriggers down, the large machines can handle 10,000-lb loads at a 20-ft. radius. These are not production excavation machines. They are designed for mobility and general-purpose work.

For selection of a hot for use on a project the following must be considered:

1) Maximum excavation depth required

2) Maximum working radius required for digging and dumping

3) Maximum dumping height required

4) Hoisting capability required (where applicable, i.e., handling pipe and trench boxes)

2.3.2 Dozer

A dozer is a tractor unit that has a blade attached to the machine's front. It is designed to provide tractive power for drawbar work. A dozer has no set volumetric capacity. The amount of material the dozer moves is dependent on the quantity that will remain in front of the blade during the push. Crawler dozers equipped with special clearing blades are excellent machines for land clearing. Heavy ripping of rock is accomplished by crawler dozers equipped with rear-mounted rippers because of the power and tractive force that they can develop.

A dozer is a tractor unit that has a blade attached to its front. The blade is used to push, shear, can, and roll material ahead of the dozer. Dozers are effective and versatile earthmoving machines. They are used both as support and as production machines on many construction projects. They may be used for operations such as

1) Moving earth or rock for short haul (push) distances, up to 300 ft (91 m) in the case of large dozers.
2) Spreading earth or rock fills.
3) Backfilling trenches.
4) Opening up pilot roads through mountains or rock terrain.
5) Clearing the floors of borrow and quarry pits.
6) Helping load tractor-pulled scrapers.
7) Clearing land of timber, stumps, and root mat.

2.3.3 Trucks

In transporting excavated material, processed aggregates, and construction materials, and for moving other pieces of construction equipment, trucks serve one purpose: they are hauling costs. The use of trucks as the primary hauling unit provides a high degree of flexibility, as the number in the total hauling capacity of a fleet. Most trucks can be operating over any haul road for which the surface is sufficiently firm and smooth, and on which the grades are not excessively steep. Some units are designated as off-highway trucks because their size and weight are greater than that permitted on public highways. Off-highway trucks are used for hauling materials in quarries and on large projects involving the movement of substantial amounts of earth and rock. On such projects, the size and cost of large trucks are easily justified because of the increased capability they provide. Trucks can be classified by many factors, including shown as Figure 2.5

1) The method of dumping the load---rear-dump, bottom-dump, side-dump
2) The type of frame---rigid-frame or articulated

3) The size and type of engine---gasoline, diesel, butane, or propane

4) The kid of drive---two-wheel, four-wheel, or six-wheel

5) The number of wheels of wheels and axles, and the arrangement of driving wheels

6) The class of material hauled---earth, rock, coal, or ore

7) The capacity---gravimetric (tons) or volumetric (cubic yards)

If trucks are purchased for general material hauling, the purchaser should select units adaptable to the multipurpose for which they will be employed. On the other hand, if trucks are to be used on a given project for a single purpose, they should be selected specifically to fit the requirements of the project.

Figure 2.5: Truck for transport in construction site project.

2.3.4 Cranes

Cranes are generally classified into two major families:

Tower Cranes and Mobile Cranes. Because cranes are used to hoist and move loads from one location to another, it is necessary to know the lifting capacity and working range of a crane selected to perform a given service. The rated load for a crane, as published by the manufacturer, is based on ideal conditions. Load charts can be complex documents listing numerous booms, jibs, and other components that can be employed to configuration that will be used.

2.3.4.1 Tower Cranes

Tower cranes provide high lifting height and good working radius, while taking up a very limited area. These advantages are achieved at the expense of low lifting capacity and limited mobility, as compared to mobile crane. The three common tower crane configurations are (1) a special vertical boom arrangement on a mobile crane (2) a mobile crane superstore mounted atop a tower, or (3) a vertical tower with a jib. The latter description is the type referred to in the United States as the European type, but is the type perceived elsewhere as a “tower crane” when this team is used with on further details.

In Thailand, the typical of cranes that almost used in high rise building construction is Top-Slewing Tower Cranes because the height is practically than Bottom-Slewing Tower Cranes shown as Figure 2.6.

Top-slewing (fixed tower) tower cranes have a fixed tower and a swing circle (“slewing ring” or “crown”) mounted at the top, allowing only the jibe (main-jib and counter-jib), tower top, and operator cab to rotate. The tower is assembled from modular sections, and hence the term “sectional tower crane,” often used in reference to this type of crane. The crane is stabilized partly at its base (by ballasts or other means of ground anchoring) and partly by ballasts on the counter-jib. In the United States, tower cranes are usually the machines of choice when

1) Site conditions are restrictive.

2) Life height and reach are great.

3) There is no need for mobility.

4) Noise limits are imposed.

Figure 2.6: Tower crane in construction site project.

Top-slewing cranes, disassembled to their basic parts, are transported by any number of large trucks to the worksite. Preferably, the site would have adequate space to store these parts for later connection to lager assemblies using a smaller mobile crane than the one needed later to erect the tower crane. These larger assemblies would then be lifted up by a bigger mobile crane for assembly and erection of the tower crane. The electing crane is almost always a mobile crane, often two mobile cranes, unless the site is to have two or more overlapping tower cranes located close enough to each other such that the big cranes can be erected first and then used to erect some of the others. Dismantling the tower crane when its service is no longer needed is essentially the same of process in reverse, except that it may become more complicated because a building is now standing where there had been an empty space when the tower crane was originally erected. Quite often, a larger mobile crane will be required for dismantling than the one used for erection. These processes take from a few days up to a few weeks, depending on the size of crane erected or dismantling crane, its location with regard to the constructed building, and accessibility of the erecting or dismantling crane.

2.3.4.2 Mobile Cranes

Today, these machines find their main use in a great variety of civil engineering projects other than building construction. Some mobile crane types, show great presence on the building construction site, whether for short-term tasks or throughout most of construction. If for no other use, they are the machines that set up the tower cranes at the onset of construction and dismantle them at the conclusion of their service on site. This is a classic demonstration of the mobile cranes main features: its capacity to handle heavy loads and its rapid development. A relatively small mobile crane has a lifting capacity equal to that of a heavy tower crane. The high-end mobile cranes can lift hundreds of tons.

1) Truck Cranes

Truck cranes are suitable mainly for short-term lifting assignment; this is not kind of a crane seen working for extended durations on construction sites. The superstructure of this crane, which includes the boom, engine, counterweight, and operator cab, is mounted on a specialized carrier truck. The crane travels the public road system essentially like any other truck but can also travel on rough road. To utilized its maximum lifting capacity, the crane must be leveled and stabilized on its outriggers while in operation; it can operate while on its wheels to only partial capacity. Because of the high loads these machine transfer to the ground through the outriggers, mats of various sizes must be used to spread the load, as depends on the soil-bearing capacity.

2) Crawler Cranes

The revolving superstructure of the crawler crane is similar to the superstructure of the truck crane but is mounted on a crawler undercarriage. This change from the truck crane has several implications, in that the crawler crane has better maneuverability and offers outrigger-free work with rapid relocation within the jobsite but requires longer transfer between sites, including loading it on a haul truck. Given these qualities, crawler cranes are particularly suitable for jobs with difficult ground conditions and for projects requiring frequent crane movement.

2.3.5 Pile – Driving

Piles can be classified on the basis of either their use or the materials from which they are made. On the basis of use, there are two major classifications: Sheet and load bearing. Sheet piles are used primarily to retain or support earth. Load-bearing piles, as the name implies, are used primarily to transmit structural loads. In general, the forces that enable a pile to support a load also cause the pile to resist the efforts made to drive a pile. Pile-driving hammers are designated by type and size.

2.3.5.1 Cast-In-Place Concrete Piles

As the name implies, cast-in-place concrete piles are constructed by placing concrete into a tapered or cylindrical hole previously driven into the ground or into a hole in the ground from which a driven mandrel (steel core) has been withdrawn. In both of these cases, the hole has been created by a driving process that displaced the ground. There are also non-displacement cast-in-place piles where the soil is removed and the resulting hole filled with concrete.

The cast-in-place displacement-type pile can be of two forms. The first involves driving a temporary steel tube with a closed end into the ground to form a void in the soil, which is then filled with concrete as the tube is withdrawn. The second type is the same except the steel tube is left in place to from a permanent casing. There piles may be tapered or of uniform section. Generally, the tapered piles are commonly referred to a as Monotube piles. Monotube piles can be either tapered or of a uniform diameter. The Monotube pile shill is driven without a mandrel, inspected, and filled with concrete. The desired length of shell is obtained by welding extensions to a standard-length shell.

There are also driven cast-in-situ concrete piles where a casing, closed at the bottom with a plug of dry concrete or gravel or with a shoe, is driven into the ground to the required depth. Concrete is then placed into the casing and a cast-in-situ pile is formed inside the casing. One particular feature of this pile is that as the casing is withdrawn and the concrete compacted, the “green” concrete will key into the borehole and thus provide skin friction between the pile and the soil. However, in the installation of this pile, care must be taken to ensure that the reinforcement cage is positioned correctly to provide adequate cover to all the reinforcement.

2.3.5.2 Pile Hammers (Allen and Lano, 2004)

Pile hammers are massive weights lifted by the energy of steam, compressed air, compressed hydraulic fluid, or a diesel explosion, then dropped against a block that is in firm contact with the top of the pile. Single-acting hammers fall by gravity alone, while double-acting hammers are forced downward by reverse application of the energy source that lifts the hammer.

2.3.6 Concrete Equipment (Nawy, 2008)

The typical concrete-construction building site will employ several or all of the following equipment types: (1) cranes, (2) material handlers, (3) concrete pumps, (4) hoists and lifts, and (5) forming systems. Concrete is commonly produced on-site only in the case of large projects requiring high concrete volumes or transportation distances that are too great for the supply of ready-mixed concrete. Earthmoving equipment is used for the initial, substructure phase of construction and often during final landscape development work but is hardly seen on the jobsite throughout construction of the structure itself.

The use of concrete as a building material involves equipment throughout production: from batching and mixing, through transporting and placing, to consolidating and finishing.

2.3.6.1 Concrete Mixers

Today, this equipment is highly automated, among other things, to ensure high concrete quality control. Where high concrete volumes are required, large mixing plant with higher output are some are sometimes used on-site for example, in dense urban areas with access difficulties due to traffic-congested roads. The great majority of today’s building site, however, use ready-mixed concrete delivered to the site from the dry or wet central plant in truck mixers, also called ready-mixed trucks.

Truck mixers the world over are of the rear-discharge type and front-discharge type but the rear-discharge type are used as well and more in Thailand. The drum in the ready-mixed concrete truck is a freefall type mixer. Freefall mixer blends concrete by lifting the ingredients with the aid of fixed blades inside the rotating drum and then letting them drop by gravitation.

When planning a pour with ready-mixed concrete, several points should be considered. The rate of concrete delivery is affected by the size of the truck, distance from the plant to the site, the number of truck mixers allocated by the plant for the specific operation, and possible delays that may be caused by heavy traffic. In terms of size organization, maneuvering space must be ensured for the large and heavy truck, as well as proper ground conditions for travel. If the site is too restricted to allow free truck movement, as is often the case in mid-city construction sites, provision should be made to allow for the nearby waiting of trucks. Such operations require thorough planning workers designed for traffic control and communication means. The Figure 2.7 Shown the example of concrete truck mixer in the construction site.

Figure 2.7: Concrete truck mixer in construction site project.

2.3.6.2 Concrete Pump

Concrete pumps transport concrete by moving it through a pipeline at high placing rates. Hence, concrete pumps are commonly used on building construction site generally serviced by cranes, for one or more of the following reasons:

(1) the crane is engaged in other lifting services, (2) a high placing output is require, or (3) the location of the cast element is outside the reach of the crane. Concrete pumps are often also seen sites where their ability to the deliver concrete while bypassing obstructions becomes useful, such as inside low-roofed spaces, for renovation work on existing building, and on sites located such that access of any other transportation means is impossible.

The three main configuration of concrete pumping equipment are (1) a pump-and-boom combination, (2) a pump with a separate pipeline, and (3) a pump and pipeline with a separate, tower-mounted boom. The first of these is particularly efficient and cost-effective in saving labor and eliminating the need for pipeline to transport the concrete. The last of these, used mostly in high-rise construction, combines elements from the former two and is a less common configuration.

But, in high rise building construction used pump with a pipeline and tower-mounted boom. So, just given the information of it only in below;

The longest boom available, nominally 210 ft long, can practically place concrete in building no higher than 14 floors, the solution is, then, to use the basic pump-and-pipeline configuration, render it with climbing capability similar to that of the internal-climbing tower crane, and enhance horizontal distribution reach and convenience by use of a boom-pump-type hydraulic articulated placing boom. This configuration, is today preferred solution for concrete placing in high-rise structures.

2.3.6.3 Power Trowels

The final operations in the production of concrete elements that involve equipment are consolidating and finishing. Immediately following placing, concrete has to be consolidating by the use of vibrators. Finishing may actually be required only in the form-free faces of the case element. Typical faces are the upper surfaces in floor slabs, where finishing to a smooth face-if required-is attained by the use of power trowels. Powered by electric motors or by diesel or gasoline engines, trowels come in either a walk-behind or a ride-on configuration.

2.3.6.4 Concrete vibrators (Andres and Smith, 2001)

Vibrators may be either internal or external. Internal vibrators must always be inserted vertically into the concrete and should be used for consolidation only, not to move concrete from one place to another within a form. External vibrators are used against the outside of forms and are most effective in producing smooth surfaces against the form faces.

Vibrating eliminates stone pockets and air bubbles in freshly placed concrete and consolidates each successive layer of concrete with the one below. This activity must also bring enough mortar to the concrete surface or the form to ensure a smooth finish. Excessive vibration should be avoided as it causes segregation by forcing the coarse aggregates away from the vibrator; resulting in pockets of cement mortar lacking in coarse aggregates. It should also be remembered that vibrating of the concrete mix increases the pressure on the formwork, so special care must be taken to ensure that the formwork is designed and constructed to withstand the additional pressure.

2.4 High-Rise Building Construction in Bangkok, Thailand

(Empolis, 2011) From information of high-rise building in Bangkok on May, 2011 that can summarize about contains building in Bangkok in term of existing building, under construction building, planned, and unbuilt shown in Figure 3.1 in below;

1. Existing Building around 786 projects
2. Under Construction Building around 76 projects
3. Planned (Get information on which buildings are planned by authorities) around 36 projects
4. Unbuilt (Building once planned for construction but for various reason never built) around 5 projects

(Department of City Planning, 2011) The Bangkok Metropolitan Administrator announced up to present time that the amount of high-rise building construction project is waiting for the construction permission around 95 high-rise building with the total used area 3,834,128.50 m^2 by separated the type of the building in the amount of floor as;

1. The range of high-rise building from 30 – 39 floors with 33 buildings. The total used area around 1,637,280.17 m^2.

2. The range of high-rise building from 20 – 29 floors with 29 buildings. The total used area around 796,524.35 m^2.

3. The range of high-rise building from 9 – 19 floors with 22 buildings. The total used area around 312,089.22 m^2.

4. The range of high-rise building from 40 – 49 floors with 7 buildings. The total used area around 733,475 m^2.

When consider in term of district found that most district that to waiting the construction permission are Huai Khwang district and Vadhana district around 9 construction projects.

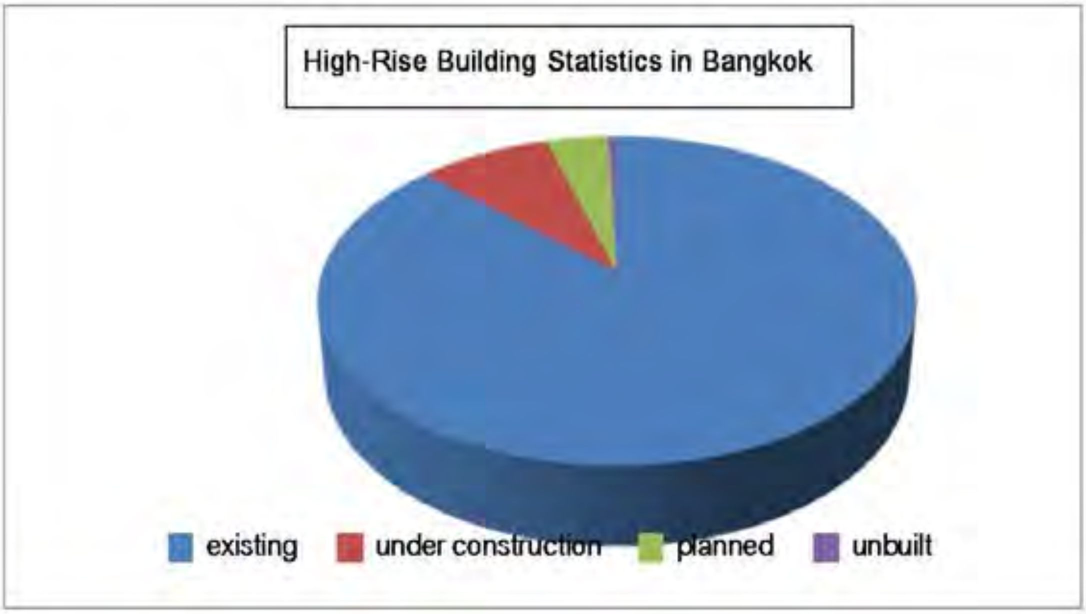

Figure 2.8 : The high-rise Building Statistics in Bangkok

2.5 Carbon Dioxide Emission Estimation (IPCC Guidelines, 1996)

Simple methods for estimation CO_2 emissions from the use of fuels assume that the carbon in the fuel used for each activity will enter the atmosphere in the short or long term. Short-term emissions are defined within the IPCC Guidelines as those occurring within twenty years of the fuel use and are almost entirely reported in the fuel combustion module. Long-term CO_2 emissions result from the final oxidation of long life materials manufactured from fuel carbon and are usually emissions from waste destruction.

Whichever method is used in underlying equation is:

$$Cr = Q \times NCV \times EF \times (1 - Sf) \times F$$

Where:

Cr : quantity of carbon released and attributed to fuel combustion (multiply by 44/12 for CO_2) expressed in kg- CO_2 unit

Q : quantity of fuel delivered to or consumed by the activity (sector) expressed in litre units

NCV : net calorific value of fuel (GJ/t unit)

EF : emission factor (more precisely, the specific carbon content, t C/TJ)

Sf : carbon storage sector, that is the fraction of carbon delivered which remains unoxidised after use of the fuel either in a product manufactured from it or because the use does not involve deliberate oxidation of the carbon content.

F : is the oxidation factor, the fraction of carbon which is oxidized during combustion.

This formula followed from the method of IPCC that called *Tier 1 methods* which is used more detailed analyzed where "Consumption rate data available". For calculated carbon dioxide emission by using the factor from table 2-1 to 2-3

Table 2 - 1: NCV and Emission Factor

NET CALORIFIC VALUES AND EMISSION FACTORS FOR OILS AS FOUND IN THE 1996 IPCC GUIDELINES		
Oil based Fuels	Net Calorific Value, NCV (GJ/t)	Emission Factor,EF (tC/Tj)
Crude oil	41 – 43 GJ/t. Depends on crude stream. Typical value 42.6 GJ/t. Not a characteristic of direct importance to the market 50 measurement is unusual.	20.00 – 21.0 tC/Tj.

Natural Gas Liquids (ethane, Propane, butane and condensate)	42 – 45 GJ/t. Composition varies considerably. Typical value 43.5 GJ/t. Local advice needed on NCV.	17.2 tC/TJ. Dependent on composition ranging from about 17.2 for light mixtures to 19.0 for condensate rich mixtures.
Oil Shale	Usually 8.6 – 11.5 GJ/t. but larger ranges are quoted.	18.9 tC/TJ
Gasoline	44.8 GJ/t	18.9 tC/TJ
Jet Kerosene	44.59 GJ/t	19.5 tC/TJ
Other Keresene	44.75 GJ/t	19.6 tC/TJ
Gas/Diesel oil	43.33 GJ/t	20.2 tC/TJ
Residual fuel oil	40.19 GJ/t	21.1 tC/T
Shale Oil	40.0 GJ/t	20.5 tC/TJ
LPG	47.31 GJ/t	17.2 tC/TJ
Ethane	47.49 GJ/t	16.8 tC/TJ
Naphtha	45.01 GJ/t	20.0 (default value)
Lubricants	40.19 GJ/t	20.0 (default value)
Petroleum Coke	31.00 GJ/t	27.5 tC/TJ
Refinery Gas	48.15 GJ/t Composition of gas varies with refinery and with operations. Local advice needed.	18.2 tC/Tj (see comment on calorific value)

(Source : IPCC Guidelines, 1996)

Table 2 - 2 : Carbon storage factor (Sf)

CARBON STORAGE FACTORS AS GIVEN IN THE 1996 IPCC GUILDELINES	
Fuel types	Storage factor
Ethane	0.8
LPG	0.8
Naphtha	0.8

Gas/Diesel oil	0.5
Natural gas	0.33
Lubricants	0.5

(Source : IPCC Guidelines, 1996)

Table 2 - 3 : Oxidation factor (F)

OXIDATION FACTORS AS GIVEN IN THE 1996 IPCC GUIDELINES	
Fuel	Fraction of carbon oxidised
Coal	0.98
Oil products	0.99
Gas	0.995
Peat for electricity generation	0.99

(Source : IPCC Guidelines, 1996)

2.6 CO_2 Emissions from Energy Consumption

From Document of Product Carbon Footprint Assessment by The Committee of Product Carbon Footprint Techniques found that the consumption of energy (electrical consumption) in 1 kilowatt – hour will emit carbon dioxide emission 0.561 kilogram – carbon dioxide. If known the amount of electrical used in construction work then it can analyze the amount of carbon dioxide emissions that occurs from energy consumption machines and equipment. (Document of Product Carbon Footprint Assessment, 2010)

2.7 Cleaner Technology – CT

Cleaner Technology is appropriate technologies combined with a good practical to produce environmental friendly products or services that increase productivity and profitability by using the principles work in monitoring the system in organization by focus on the fully system and no impact to environment. It approach to process of monitoring and assessments continuously for reduce the use of natural resources, protected the waste hazard at the resources including reduction cost in organization and impact to environmental. (Srisatit, 2006)

2.7.1 Principle of CT

Cleaner Technology (CT) or called Pollution Prevention (2P), Cleaner Production (CP), and Waste minimization is to protected waste hazard at the recourse instead of treatment at the end. So, Cleaner Technology is application to improve production process continuously for full efficiently management.

Therefore, the principle of Cleaner Technology means:

1) **Reduction the pollution at the sources** is reducing the product waste and impact to environmental minimum but life cycle longer. Moreover, changing the production process by use raw materials that are less toxic, recycling materials, or improving the system to full efficiently including control the system to decrease losing.

2) **Using recycling processes** may separate to 2 characteristics; (1) reuse without any process to modification and (2) recycle that to improve the quality before.

3) **Conserving the natural resources and energy in production** is control the process properly, saving, and not use without benefit such as using water in production process properly and not it leaked. Moreover, the energy consumption included fuel, gas or electrical that the organization must proposed the quality methods and properly with a chance or during time.

2.7.2. Procedures of CT

Process of CT for organization may separate 6 mains step following;

1) **Established CT** means obtaining commitment from management division, established the committee of CT, proposed the targeting, identify problems and improvement.

2) **Gathering data of organization** means collect all of data in organization to analyst, survey the location, and identify alternatives in the beginning steps.

3) **Selection properly alternatives** means selecting alternatives along with necessity by using a simple screening or using experiences of committee.

4) **Assessment properly alternatives** means assessment of unclear alternatives in technical terms, environmental terms and economic terms before summarize that chose the properly selection.

5) **Process of improvement** means surveying for design, improvement and following comparison, measuring of work including new process of CT for determined a new selection.

6) **Process assessment** means evaluate the CT work in organization to designate to achievements and failing for identify to resolve the problem with continuously quality management.

2.8 Related Research

2.8.1 Estimation the Energy Consumption and CO_2 Emission in Building Construction

1) **Tatsuo, Michiya, and Tetsuo. (1993)** studies about the estimation of energy consumption and amount of pollutants due to the construction buildings from 1,502 m^2 to 21, 6000 m^2 by using Inter-Industry Relations Table in Japan with The Leontief inverse matrix, found that the total consumption of energy and major resources was linked to the production of pollutants and industrial waste due to the construction of office buildings. The total energy consumption caused by construction of office building is 8-12 GJ/m^2 with CO_2 production is 750-1140 kg of floor area. Structure work is shown to be high in energy consumption and CO_2 exhausted per unit cost of construction.

2) **Andrew, and Brian. (1993)** studies about energy and carbon dioxide implication of building construction by compared for typical commercial, industrial and residential buildings, using New Zealand as an example. They summarized that reinforced concrete and structural steel buildings require similar amounts of energy and result in similar level of CO_2 emissions, both being much more than the equivalent values for wood buildings. An additional benefit of wood construction is the carbon which is “locked up” in wood products for the life of the building.

3) **Michiya, Tatsuo, and Kiyoshi. (1995)** studies about the estimation of energy consumption and CO_2 emission due to housing construction in Japan by using the Input/output Table of Japan. They found that;

3.1 Energy consumption for construction is 8-10 GJ per m^2 of floor area for multi-family SRC houses, 3 GJ for wooden single-family houses, 4.5 GJ for light-sumption due to construction of a wooden house is approximately 1/3 of that of a SRC multi-family house and 60% of that for a lightweight steel-structure single-family house. In terms of the construction, the wooden house has less impact on the global environment.

3.2 CO_2 emission resulting from construction is 850, 250 and 400 kg/m^2 , respectively.

3.3 The construction of wooden house has less impact on the global environment compared with other types of house.

4) **Michiya, and Tatsuo. (1998)** studies the estimation of life cycle energy consumption and CO_2 emission of office buildings in Japan by using a method based on the of I/O tables was applied to estimate the life cycle energy consumption and CO_2 emission of office buildings. Energy consumption is 0.49 GJ/m^2 and CO_2 emission is 36 kg/m^2 for Reinforce Concrete (RC) office buildings. Therefore, the energy consumption and CO_2 emission in the demolition work contribute relatively small amounts to their respective totals.

5) **Hui et al., (2010)** studies about greenhouse gas emissions in building construction: A case study of one Peking in Honk Kong. The results show that 82-87% of the total GHG emissions are from the embodied GHG emissions of building materials, 6-8% are from the transportation of building materials, and 6-9% are due to the energy consumption of construction equipment.

6) **Adolf, and Aidan., (2010)** studies the Input-output analysis of Irish construction sector greenhouse gas emissions by estimates energy and GHG emissions intensities of the Irish construction sector and subsectors and estimates its contribution to Irish national emissions. Energy and emissions intensities are estimated using input-output analysis techniques applied to Irish construction sector. In 2005 the Irish construction sector was responsible for the emission of 13.81 $mtCO_{2eq}$, comprising 2.37 mt (17%) of direct on-site emissions, 5.69 mt (41%) upstream indirect domestic emissions and 5.75 mt (42%) upstream indirect emissions outside the state. Domestically arising direct and indirect emissions accounted for 3.44% and 8.26% of national emissions respectively.

This will lead to significant GHG emissions reductions from the sector and has undoubtedly contributed to national reductions from all has undoubtedly contributed to national reductions from all economic sectors over this period. However, any reductions are likely to be short-lived and when construction activity returns to historic levels (15-20% of GNP), emissions are again likely to approach the quantities estimated above.

Existing emissions mitigation policies already target many aspects of construction sector supply chains: the cement industry is one such example where the EU ETS disincentivises emissions. However, given the potential importance of the construction sector to national emissions, there is further scope for the implementation of policies which specifically target it. Two such policies are proposed: direct emissions mitigation through a construction Eco-Driving initiative; and the provision of information to allow the design and specification of low-emissions materials followed by regulation of construction procurement to achieve maximum construction emissions standards. Such policies could have reduced Irish national emissions by 0.5% and 1.6% respectively in 2005.

7) **Raymond. (1999)** studies about energy and greenhouse gas emission associated with the construction of alternative structural systems by examination of the energy and greenhouse emissions associated with the on-site construction of a selection of alternative wood, steel and concrete structure assemblies.

The construction energy and greenhouse gas emissions were examined in five general categories:

7.1 The transportation of the construction crew to and from the building site for the duration of their construction task.

7.2 The transportation of materials from a distribution centre to the building site.

7.3 The transportation of equipment specific to the construction task to and from a central depot to the depot to the building site.

7.4 The use of on-site equipment specific to the construction task.

7.5 Supporting processes such as form-work and temporary heating.

However, whereas materials manufacturing is energy and machinery dependent, a considerable amount of building construction is labor intensive. The more labor intensive a process, the greater the amount of worker transportation. The transportation of workers to and from the building site represents the largest proportion of construction energy use for many structural assemblies and, when included in the analysis, makes construction a much larger proportion of their initial embodied energy than is currently assumed.

8) **Diamoudi, and Tompa. (2008)** studies about Energy and environmental indicators related to construction of office buildings. The research investigates the role of different construction materials and quantifies them in terms of the embodied energy and the equivalent emissions of CO_2 and SO_2 in contemporary

office buildings. It was shown that the embodied energy of the structure's building materials (concrete and reinforcement steel) represents the largest component in the building's total embodied energy of the examined buildings, varing from 66.73% to 59.57%, while the embodied energy of the building envelope's materials represents a lower but significant proportion of the building's total embodied energy. When the construction elements are examined, the slabs have the higher contribution at the embodied energy to the studied buildings and from the envelope an element, the external wall is contributing the maximum in the overall embodies energy of the building. The embodies energy correspondence varies between 12.55 and 18.50% of the energy needed for the operation of an office building over a 50 years life.

2.8.2 Cleaner Technology application

1) **Walter, (1992)** studies about Cleaner technologies in Italy: problems and perspectives. In Italy, the historic of industrialization is characterized by the settlement, in very concentrated center areas, of many environmentally critical activities like petrochemical plants, steel factories, non ferrous metals treatment plants, tanneries, pulp and paper firms, ceramics, textiles. The main problem related to the enormous number of small and medium-sized enterprises, operating in Central and Northern Italy because they are not able to acquire skills and resource by themselves in order to manage a cleaner production approach. So, small and medium-sized enterprises present a crucial subsystem: they need help in terms of technical training, financial assistance, and networking actions in order to be enabled facing the challenge. Moreover, education and policies have to be reoriented in the sense of internalizing the basic cleaner production concepts.

2) **Carol, (1998)** studies the cleaner production in New Zealand because of many key personnel in businesses have little or no knowledge of environmental concerns or of the cost of pollution or waste production. Its appear that they are not serving to encourage companies to implement cleaner technologies production program.

3) Arne, and Borge, (2000) studies about employee participation and cleaner technology: learning processes in environmental term. Based on practical experiments in five Dinish firms within different industrial sectors, the project concluded that employee participation can have a strong effect on changing working routines, affecting behavior and increasing environmental consciousness. The research has stressed that employee participation was not just about information. The environmental teams formed within the companies have been a guarantee that the knowledge and experience of the employee as well as consultation and negotiation have been pivotal point of the environmental activities. In this way participation has given the employees a relatively high degree of influence on activities, just as there has been a forum to discuss the conflicts and problems that have arisen during the process. The environmental teams have ensured influence and conflict resolution.

4) Salvador, Glasson, and Piper, (2000) studies about Cleaner Production (CP) and environmental impact assessment: a UK perspective. Cleaner Production has been the subject of great interest and development over this decade and the implementation of the IPPC process in the EU will certainly contribute to increasing and improving CP practices. The IPPC and EIA represent important processes for a preventative and integrated approach to the reduction of environmental problems and these processes should be strengthened as far as possible.

CHAPTER III
RESEARCH METHODOLOGY

The research aims to estimate the amount of CO_2 emissions in high-rise building construction and suggest the method to the practical case for reducing the CO_2 emissions by using Cleaner Technology. For the data collection, the research is collected the data from the recourse as raw data available from the construction report and average of data estimation from expert at the real site construction.

3.1 Research Planning and Design

The research planning begins with the study about the reduction CO_2 emission related to construction equipments in high-rise building by using Cleaner Technology follow;

1. Study and review the information related through many sources such as textbooks, international journal, construction equipment manual and internet web pages.
2. Data collection at the real site of the construction project
3. Estimate the amount of carbon dioxide that caused from oil fuel consumption equipments and energy consumption equipments by using IPCC formula.
4. Suggest the Cleaner Technology concept to reduce CO_2 emission.

The overview of the research shows as the frame work in the Figure 3.1.

3.2 The Detail of the Research

3.2.1 Study detail and information of high-rise building construction activities from construction report of the project for easily to gathering and estimating the data. Then, the research divided the construction activity as 3 main activities:

1.1 Structural Activities consists of 11 sub-activities

1. Site Preparation
2. Piling Work
3. Excavation Work

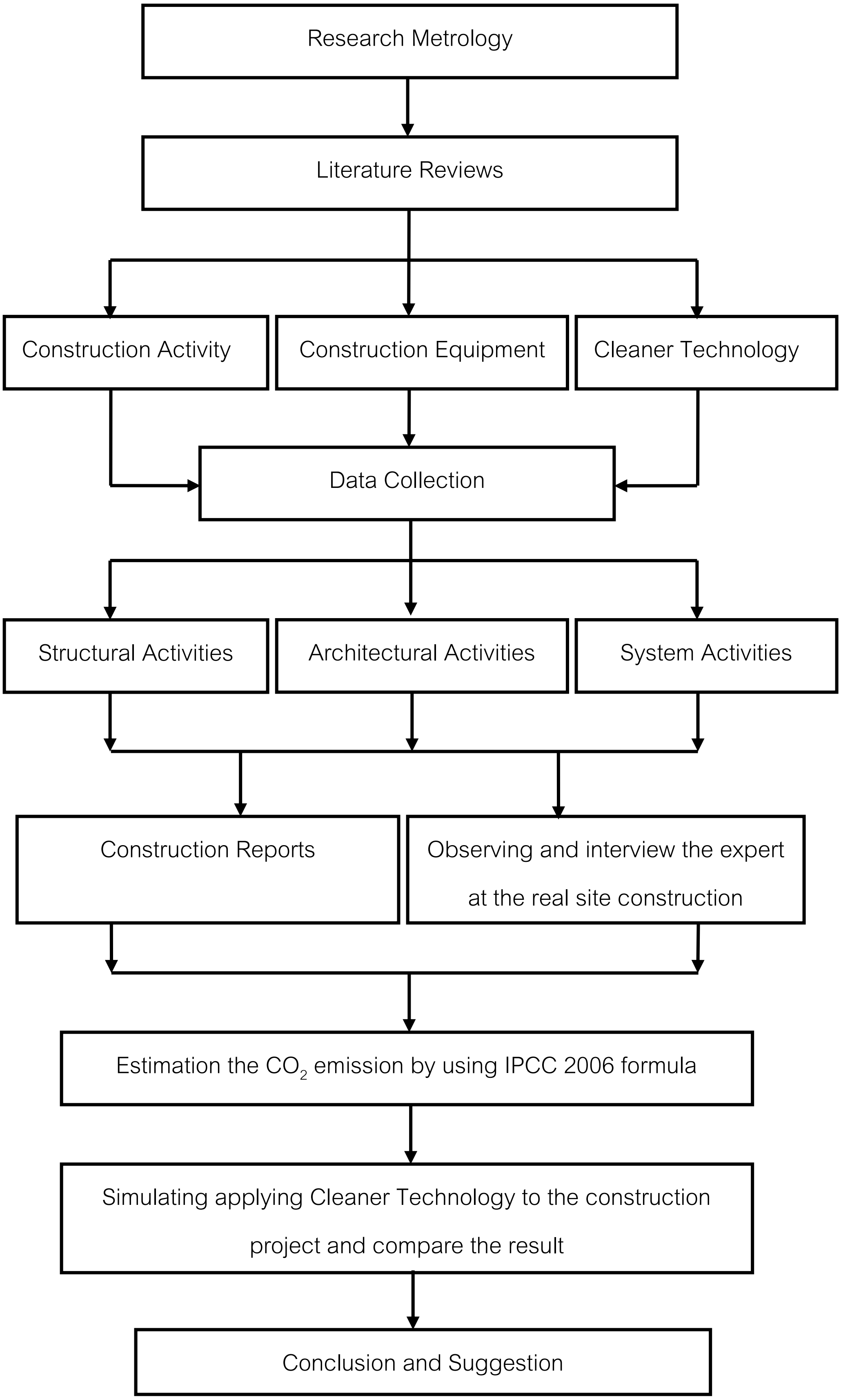

Figure 3.1 Research design in this study

5.1 Scaffolding

5.2 Wooden formwork structure

5.3 Post tension slab work

5.4 Reinforcement Work

5.5 Steel form demolition work

6. Colum Work

6.1 Scaffolding

6.2 Steel form work

6.3 Concrete placing work

6.4 Reinforcing work

6.5 Steel form demolition work

7. Precast Installation

8. Water tanks on the property

9. Pipelines and Utilities Work

10. Roads and Surrounding ground

11. Labors and Material transport

1.2 Architectural Activities consists of 8 sub-activities

1. Masonry Work

2. Rendering Work

3. Ceiling Work

4. Doors and Windows Work

5. Sanitary and Hygiene fitting

6. Painting Work

7. Topping covering Work

8. Tiles, Floor and Terrazzo Covering Work

1.3 System Activities consists of 10 sub-activities

1. Elevator System

2. Air-conditioning System

3. Cold water System

4. Waste water System

5. Vent System

6. Soil System

7. Storm drainage System

8. Wiring System

9. Electrical Supply System

10. Fire alarm System

3.2.2 Study detail of construction equipments using in this project as sources in each construction activities by follows the construction report. Then the research divided the equipment into 2 types of equipment as:

1. Construction equipments to consumed *oil fuel*

1.1 Back hoe (Excavator)

1.2 Generator

1.3 Dump truck

1.4 Generator

1.5 Concrete truck

1.6 Drilling rig crane

1.7 Truck with crane

1.8 Mobile concrete pump

1.9 Mobile crane

1.10 Trailer

1.11 Rolling compactor

2. Construction equipments to consumed *electrical energy consumption*

2.1 Tower crane

2.2 Site elevator (during construction phase)

3.2.3 Review international paper and journal related with the CO_2 emissions from building construction.

3.2.4 Estimate the working times of construction equipment at each construction process in units of hours by collecting the data from construction report and estimating from the project engineer.

3.2.5 Estimate and revise the engine consumption of equipments to efficiently 80% of the engine consumption by follow the specification manual of equipment.

3.2.6 Estimate the total amount of oil fuel and electrical energy consumption to use in working times.

3.2.7 Study Emission Factor and Estimate amount of carbon dioxide that to emitted in building construction.

1. Oil fuel consumption equipment

From documents of IPCC 2006 guidelines for National Greenhouse Gas Inventories for Stationary Combustion (Tier 1 methods), equation shown below;

$$Cr = Q \times NCV \times EF \times (1 - Sf) \times F$$

When:

Cr = amount of carbon released from fuel combustion in kilogram-CO_2 (Cr must multiply by 44/12 to changes in CO_2 units)

Q = Amount of oil fuel consumption in expressed in litre units

NCV = 43.33 GJ/t

EF = 20.2 tC/TJ

Sf = 0.5

F = 0.99

2. Energy consumption equipment

From Document of Product Carbon Footprint Assessment found that the consumption of electric energy 1 kilowatt – hour will emit carbon dioxide emission 0.561 kilogram – carbon dioxide, equation shows as ;

$$CE = Q \times 0.561$$

When:

CE = Amount of carbon released from electric energy combustion in units of kilogram-CO_2

Q = Amount of electricity consumption in expressed in kilowatt – hour units

3.2.8 Collect the all of amount of carbon dioxide in each construction activities.

3.2.9 Simulate applying Cleaner Technology principles to the construction activity for reduces carbon dioxide emission.

3.3 Data Collection

Due to the research study about the estimation of CO_2 emission in high-rise building construction, therefore depend upon the factor that to influence the estimation. The important of data input to estimate in this research are composed

1. The quantity of equipment that used in each sub-activity
2. Working time of equipment in each activity that to record in monthly expressed unit of *Days*
3. Working time of equipment in each activity that to record in daily expressed unit of *hours per day*
4. For the dynamic equipment which not working in the site but also to transport the raw material from supplier to site project as to collect in term of hauling distance in *kilometers per litre.* For this project just select the equipment to identify the hauling distance are concrete truck, trailer and truck with crane.
5. The rate of consumption equipment that to used in this project.

The method to collect all of these come from available construction report includes daily report, weekly report and monthly report. But some report were not recorded the data or report losing then another method to collect the data is observing and interviews with the expert at construction project such as Project engineer, M & E engineer, Site engineer and Contractor to estimate the average of working time in one day of equipment and explained the procedure of construction in each activity.

In such case rate of consumption equipment, the research used the equipment manual as sources to provides the information about rate of consumption but in the actual construction, the equipment is not the new engine to used but also the equipment passed many construction project then the research will adjusted the efficiently to 80% of the engine consumption. The objective of data collection is to estimate the engine consumption of the equipment to identify the CO_2 emission in next step of the research.

3.4 Data Estimation

When data collection available to estimated, the research summarized the kind of estimation into 2 estimation as Table 3-1 before to last step estimate the CO_2 emission

Table 3-1 shows the relationship between Operation Equipment and Activity

Type of Equipments	Operation of Equipment	
	Single Activity	Overlapping Activity
Statics Equipment	Drilling rig crane	Backhoe
	Mobile concrete pump	Generator
	Rolling compactor	Tower crane
		Site elevator
Dynamic Equipment	Dump truck	Truck with crane
	Concrete truck	
	Trailer	

1. Estimate the working time depends upon the operation of equipment.

In practical case, when the research was observed that some equipment just response the specifically task on time by time, just working in boundary at the site construction project that called *Single Activity* such as Drilling with crane, Mobile concrete pump, and Rolling compactor. Moreover, some equipment working in overlapping time because equipments is limited by the number of equipment but can be working many work in the times that called *Overlapping Activity* such as Backhoe, Generator, Tower crane and Site elevator. The method to estimate the working time of these is the same method but different the sources of data available. The Single Activity can be collect the data directly from construction report because the contractor can be record and control the working time directly but the equipment in Overlapping Activity just recorded sometimes then the research used the data from average estimation of project engineer at the site. The example of estimation the working time shows in below (Appendix A).

Example: The working time of Backhoe in Site preparation work

Data available from construction record are composed

- Number of equipment is 2 Backhoes
- Working time in monthly is 15 Days
- Working time in daily is 8 hours

Then, the total working time in hour unit is 2 Backhoes x 15 Days x 8 hours = 240 hrs

2. Estimate the rate of consumption equipment depend upon the type of equipment which to consume oil fuel and electricity consumption.

The source of information about the rate consumption from equipment specification manual, the manual giving the engine consumption in units of *litre per hour* for oil fuel consumption equipment and *kilowatt per hour* for electricity consumption equipment but in the practical case, the equipment used passing many project or used long time then the research adjust to the engine efficiency to 80% due to the efficiency of the equipment decreasing. The example of estimation the rate of consumption shows in below (Appendix A).

Example: The rate of oil fuel consumption of Backhoe in Site preparation work

Data available from equipment manual is 6 litre/hour but adjusting the efficiency to 80% of the engine consumption is (6 litre/hour x 0.2) + 6 litre/hour = 7.2 litre/hour

Ex*ample:* The rate of electricity consumption of Tower crane in Foundation work

Data available from equipment manual is 75 kilowatts/hour but adjusting the efficiency to 80% of the engine consumption is (75 kilowatts/hour x 0.2) + 75 kilowatts/hour = 90 kilowatt/hour

Some equipment response the task by transport the construction material from supplier to site construction project that means the influence factor of this equipment is the hauling distance expressed in unit of *kilometer per litre.* The example of estimation the rate of consumption shows in below (Appendix A).

Example: The rate of oil fuel consumption of Concrete truck in Foundation work

Data available from equipment manual is 3 km/litre but adjusting the efficiency to 80% of the engine consumption is 3 x 0.8 = 2.40 litre/km. In this project used the services of concrete plant which is located as 15 kilometers from construction project then the hauling distance is 15 x 2 = 30 kilometers. Therefore, Foundation work used 135 of concrete truck, estimated the total of hauling distance related with the amount of concrete truck is (135 concrete truck x 30 kilometers) = 4,050 kilometers and estimated the rate of oil fuel consumption 4,050 kilometers / 2.4 litre/km = 1,687.5 litre.

3.5 Example of CO_2 Emission Estimation

1. Foundation work used a working time in phase around 14 days of the monthly record.

2. Construction equipment used in Foundation work is composed 2 types as;

2.1 Oil fuel consumption of construction equipment

- 2 for Backhoe
- 1 for Generator
- 63 for Concrete truck
- 1 for Mobile concrete pump

2.2 Electricity consumption of construction equipment

- 1 for Generator

3. Estimate the working time of construction equipment in hours units as;

3.1 Oil fuel consumption of construction equipment

- Backhoe used in working time 8 hrs/day x 14days X 2 for Backhoe = 224 hours
- Generator used in working time 8 hrs/day x 14days x 1 for Generator = 112 hours
- Mobile concrete pump used in working time 3 hrs/day x 14days x 1 for Mobile concrete pump = 42 hours

3.2 Electricity consumption of construction equipment

- Tower crane used in working time 4 hrs/day x 14days x 1 for Tower crane = 56 hours

4. For moving equipment used in Foundation work is Concrete truck for transported from the plant to the site that the research estimated the working time in kilometers unit by using hauling distance as

- The hauling distance in this construction project around 15 x2 = 30 km then the hauling distance is 30 km x 63 for concrete truck 1,890 km.

5. Consumption rate of the engine in each type as

5.1 Oil fuel consumption of construction equipment

- Backhoe, rate of consumption 6 litre/hour
- Generator, rate of consumption 19.50 litre/hour
- Concrete truck, rate of consumption 3 km/litre
- Mobile concrete pump, rate of consumption 15.40 litre/hour

5.2 Electricity consumption of construction equipment

- Tower crane, rate of consumption 75 kw.

6. Revise the specification of the engine in efficiency 80 % of the real construction work because all of equipment that used a long time

6.1 Oil fuel consumption of construction equipment

- Backhoe, adjusting rate of consumption 7.20 litre/hour
- Generator, adjusting rate of consumption 23.40 litre/hour
- Concrete truck, adjusting rate of consumption 2.40 km/litre
- Mobile concrete pump, adjusting rate of consumption 18.48 litre/hour

6.2 Electricity consumption of construction equipment

- Tower crane, adjusting rate of consumption 90 kw.

7. Estimate the amount of oil fuel and electricity consumption in each equipment as

7.1 Oil fuel consumption of construction equipment

- Backhoe = 7.20 litre/hr x 224 hrs = 1,612.80 litre
- Generator = 23.40 litre/hour x 112 hrs = 2,620.80 litre
- Concrete truck 2.40 km/litre divided by 1,890 kms = 787.50 litre
- Mobile concrete pump18.48 litre/hour x 42 hrs = 776.16 litre

7.2 Electricity consumption of construction equipment

- Tower crane 90 kw x 56 hrs = 5,040 kw.

8. Estimate the CO_2 Emission as

8.1 Oil fuel consumption of construction equipment

$$Cr = Q \times NCV \times EF \times (1 - Sf) \times F$$

When:

Cr = amount of carbon released from fuel combustion in kilogram-CO_2

(Amount CO_2 caused of fuel combustion that calculate by Cr multiply with 44/12)

Q = Amount of fuel that consumed in working time expressed in litre units

NCV = 43.33 GJ/t

EF = 20.2 tC/TJ

Sf = 0.5

F = 0.99

Therefore as,

Cr = Q (litre) x 0.89 kg/litre x 10,294 kg-cal/kg x 4.1868/1,000,000 GJ/kg-cal x 20.2 kg/GJ x 1 x 0.5 x 44/12; Summarized in Excel for estimate that

Cr (kg- CO_2) = Q (litre) x 1.42053

- Backhoe, 1,612.80 litre x 1.42053 = 2,291.03 kg-CO_2
- Generator, 2,620.80 litre x 1.42053 = 3,722.90 kg-CO_2
- Concrete truck, 787.50 litre x 1.42053 = 1,118.87 kg-CO_2
- Mobile concrete pump,776.16 litre x 1.42053 = 1,102.56 kg-CO_2

8.2 Electricity consumption of construction equipment

- Tower crane, 5,040 kw. x 0.561kg-CO_2 / kw-hr = 2,827.44 kg-CO_2

Therefore, Foundation work released the CO_2 emission approximately 11,062.8 kg-CO_2

Table 3-2 show the example of estimation CO_2 emission by using Microsoft Excel 2007

January 25 – February 25, 2010 (31 days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working time (Day)	Working time (hr/Day)	Total Working time (hr.)	Total Distance (km)	Oil fuel	Unit	Efficiency 80%	Unit	Total Fuel Consumption	Unit	CO_2 kg	Total CO_2 kg	CO_2 (kg./Month)	Total CO_2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/month)	Electricity Charge(Bath)	Electricity Charge(Bath/month)
Structural Activities																						
1.Site preparation	15	Back hoe	99	2	15	8	240	-	6	L/h	7.2	L/h	1728.00	L	2454.68	2482.64	4909.35	4965.29	50855.04	101710.08	0.00	0.00
		Dump truck	114	3	7	5	105	63	4	Km/L	3.2	Km/L	19.69	L	27.97		55.93		579.40	1158.81	0.00	0.00
2.Pilling work	31	Back hoe	99	2	31	8	496	-	6	L/h	7.2	L/h	3571.2	L	5073.00	18495.3	4909.35	17898.68	105100.42	101710.08	0.00	0.00
		Generator	60	1	31	8	248	-	19.5	L/h	23.4	L/h	5803.21	L	8243.62		7977.7		170788.18	165278.88	0.00	0.00
		Drilling rig crane		1	31	8	248	-	6.25	L/h	7.5	L/h	1860	L	2642.19		2556.95		54739.8	52974.00	0.00	0.00
		Mobile crane	169	1	31	8	248	-	6	L/h	7.2	L/h	1785.6	L	2536.5		2454.98		52550.21	50855.01	0.00	0.00

CHAPTER IV

RESULT AND DISCUSSION

4.1 Project Description

As the case study, the research is used the high rise building construction project of Bangkok Horizon Phetkasem by Chaopraya Mahanakorn Public Company Limited (CMC GROUP) where the project is located at Soi Phetkasem 31/1, on Phetkasem Road, Phasi Charoen District, Bangkok, Thailand as shown in Figure 4.1

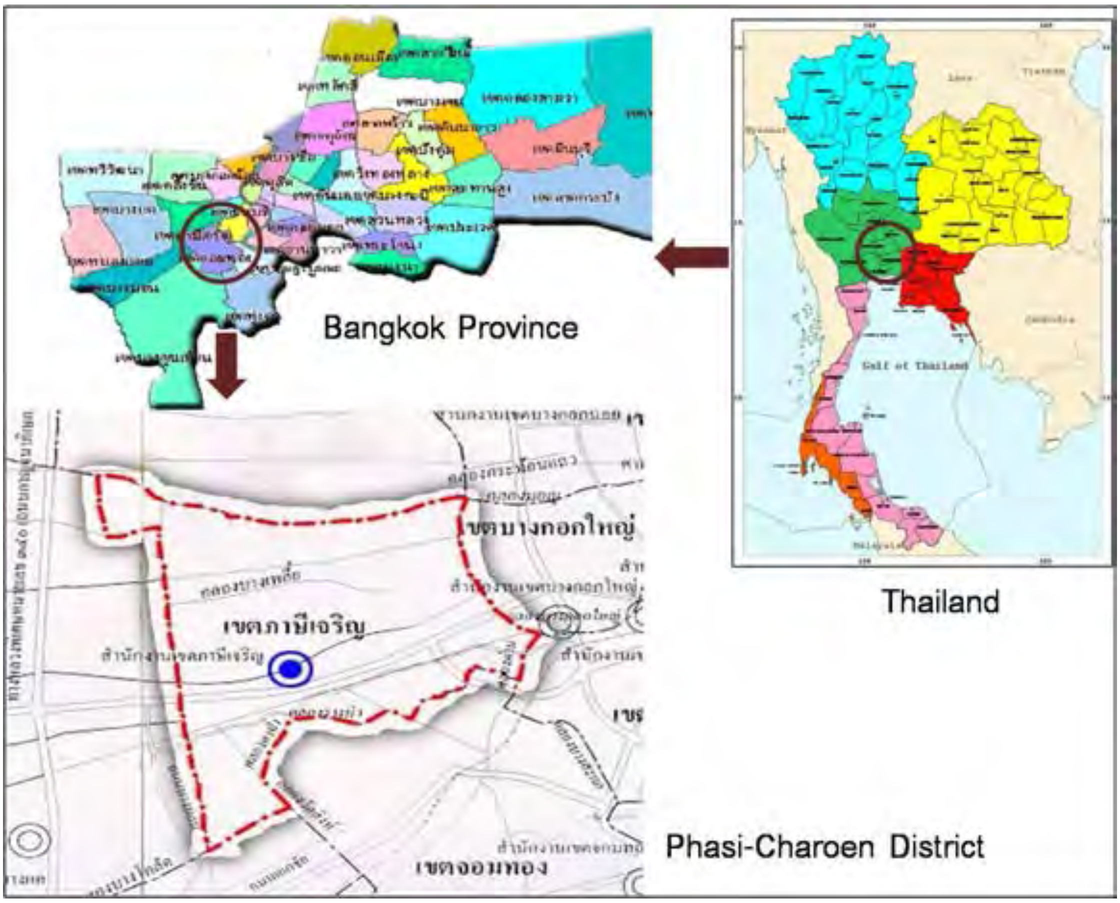

Figure 4.1 Site location of the construction project

The type of the project is residential building (Condominium) in Modern Contemporary Architectural style. The construction project is 27 storeys with 417 units by separated size of units $< 35\ m^2$ is 372 units and $> 35\ m^2$ is 45 units includes site area

4,558 m^2 and the construction area of 22,556.26 m^2 with the building height of 102.84 meters as the Figure 4.2 shown the perspective of the project. The overall construction project value 362 million Baht; (excludes the Preparatory Work 8.239 million Baht) Structural Work 102.945 million Baht, Architectural Work 120.249 million Baht (excludes Interior and Landscape Architectural Work 43.505 million Baht) and 87.062 million Baht of System Work with the total construction time project around 660 days.

The project site area is located in Prasricharoen District, along the Phetkasem Road that the district area around 17.18 km^2 with population total of 130,490 people as of December 2011, the total population was divided into 61,556 males and 68,937 females then the population density around 7,595 people / m^2 with all households around 44,293 households. Due to the construction site project area is located in the center of district surrounded by many factories, minitheater, café & restaurant, supermarket and department store then the traffic is quite high cause traffic congestion in travel and transport material and equipment delayed.

Figure 4.2 The perspective of the project

Such in construction detail, the support frame of the high-rise building construction project is constructed of reinforced concrete. Part of pilling work, used the total of pilling in wet process method 124 piles by divided into 2 diameter of the pile as

4.1.1 Diameter of 1 meter, used the total of pile 73 pile at the 50 meter of the depth

4.1.2 Diameter of 0.80 meter, used the total of pile 51 pile at the 32 meter of the depth.

Concrete material used as the main material of the overall project since foundation to super structure of the building around 11,456 m^2 but different slump setting. The internal and external walls were constructed by setting 1,800 sheet of precast concrete.

4.2 Project Activity

The research divided the construction project into 3 main activities which are Structural Activities, Architectural Activities and System Activities as Table 4-1:

Table 4-1 Detail in each activities that to studies in this research

1. Structural Activities	2. Architectural Activities	3. System Activities
1.1 Site preparation work	2.1 Masonry work	3.1 Elevator system
1.2 Piling work	2.2 Rendering work	3.2 Air-conditioning
1.3 Excavation work	2.3 Ceiling work	3.3 Cold water system
1.4 Foundation work	2.4 Door and window work	3.4 Waste water system
1.5 Floor work	2.5 Sanitary & hygiene fitting	3.5 Vent system
1.5.1 Scaffolding work	2.6 Painting work	3.6 Soil system
1.5.2 Wooden form work	2.7 Topping covering work	3.7 Storm drainage
1.5.3 Post tension slab	2.8 Tile, floor & terrazzo work	3.8 Wiring system
1.5.4 Reinforcing work		3.9 Electrical supply

1.5.5 Steel form demolition		3.10 Fire alarm system
1.6 Colum work		
1.6.1 Scaffolding work		
1.6.2 Steel form work		
1.6.3 Concrete placing		
1.6.4 Reinforcing work		
1.6.5 Steel from demolition		
1.7 Precast installation		
1.8 Water tank on the building		
1.9 Pipeline and utility work		
1.10 Road and surrounding		
1.11 Transport labor & material		

Moreover, the research also focusing on the Heavy Equipments in the deep details for studies the estimation of CO_2 emission to find which the most equipment released CO_2 product by separated the Heavy Equipment in each Activity. In this project, the researcher was observed at the construction site to selected the main Heavy Equipment which was to move the progressing of construction for estimating the CO_2 emission as Table 4-2:

Table 4-2 Specification of Heavy Equipments to estimated in this construction project.

Equipment	Name	Model	Power(kw)	Oil fuel consumption	Efficiency 80%
1.Tower crane	Potain(Fiexed angle)	FO/23 B	75	-	90 kw
2.Site elevator	Credo	XK21-116	66	-	79.2 kw
3.Excavator	Komatsu	PC 200	99	6 l/h	7.2 l/h
4.Generator	Nippon Sharyo	NES 60	60	19.5 l/h	23.4 l/h
5.Concrete truck	Nisson	CW 430	280	3 km/l	240 km/l
6.Trailer	Nisson	FE6TC-21	184	4 km/l	320 km/l
7.Mobile concrete pump	Putzmeister	42X	265	15.4 l/h	18.48 l/h

8.Drilling rig crane	Liebherr	LRB 255	605	6.25 l/h	7.5 l/h
9.Mobile crane	Nisson	PE6	169	6 l/h	7.2 l/h
10. Rolling compactor	Sakai	SV505D	93	8 l/h	9.60 l/h
11.Truck with crane	Tanado	2R 803	92	4 km/l	320 km/l
12.Dump truck	Hino	716	114	4 km/l	320 km/l

Table 4-3 List of construction equipment each sub-acticities of Structural Activities.

Structural Activities	
Sub-activities	**Construction Equipments**
1. Site preparation	1. Back hoe
	2. Dump truck
2. Pilling work	1. Back hoe
	2. Generator
	3. Drilling rig crane
	4. Mobile crane
3. Excavation work	1. Back hoe
4. Foundation work	1. Back hoe
	2. Generator
	3. Tower crane
	4. Concrete truck
	5. Mobile concrete pump
5. Floor work	
5.1 Scaffolding	1. Tower crane
	2. Truck with crane
5.2 Wooden formwork structure	1. Tower crane
	2. Truck with crane
5.3 Post tension slab work	1. Tower crane
	2. Concrete truck
	3. Mobile concrete pump
5.4 Reinforcing work	1. Tower crane
	2. Truck with crane
5.5 Steel form demolition work	1. Tower crane
6. Colum work	
6.1 Scaffolding	1. Tower crane
	2. Truck with crane
6.2 Steel form work	1. Tower crane
	2. Truck with crane
6.3 Concrete placing work	1. Tower crane

	2. Concrete truck
	3. Mobile concrete pump
6.4 Reinforcing work	1. Tower crane
	2. Truck with crane
6.5 Steel form demolition	1. Tower crane
7. Precast installation	1. Tower crane
	2. Trailer
8. Water tanks on the property	1. Tower crane
	2. Concrete truck
9. Pipelines and utility work	1. Back hoe
	2. Tower crane
10. Roads and surrounding ground	1. Back hoe
	2. Rolling compactor
	3. Concrete truck
11. Labors and material transport	1. Site elevator

Table 4-4 List of construction equipment each sub-acticities of Architectural Activities.

Architectural Activities	
Sub-activities	**Construction Equipments**
1. Masonry work	1. Tower crane
2. Rendering work	1. Tower crane
3. Ceiling work	1. Site elevator
4. Doors and window work	
5. Sanitary and hygiene fitting	
6. Painting work	
7. Topping covering work	
8. Tile, floor, and terrazzo work	

Table 4-5 List of construction equipment each sub-acticities of System Activities.

System Activities	
Sub-activities	**Construction Equipments**
1. Elevator system	1. Tower crane
2. Air-conditioning	1. Site elevator
3. Cold water system	1. Tower crane
4. Waste water system	
5. Vent system	
6. Soil system	
7. Storm drainage system	
8. Wiring system	1. Site elevator
	2. Truck with crane
9. Electrical supply	1. Site elevator
10. Fire alarm system	1. Tower crane

4.3 CO_2 Emission Estimation

The research estimated the CO_2 estimation by using the formula of Intergovernmental Panel on Climate Change (IPCC) Guideline Version 2006 in Tier 1 methods which is estimated in underlying formula as:

$$\underline{Cr = Q \times NCV \times EF \times (1 - Sf) \times F}$$

Where:

Cr: quantity of CO_2 released in kilogram- CO_2 unit

Q: quantity of oil fuel consumed by the activity (sector) expressed in litre units

NCV: 43.33 GJ/t

EF: 20.2 tC/TJ

Sf: 0.5

F: 0.99

For Energy Consumption, the formula estimated from Document of Product Carbon Footprint Assessment when known the quantity of electricity in construction work as:

$$\underline{Q = 0.561 \times E}$$

Where:

Q: Amount of CO_2 emission express in kilogram-CO_2 unit

E: Quantity of electricity that to consumed in each work express in kilowatt unit

Then, we used the formula to estimate the CO_2 emission by using spread sheet in Microsoft Excel 2007 at each construction activity, the Table 4-3 shows the example of estimation CO_2 emission since input the related factor to estimating the equipment consumption until the final results are amount of CO_2 emission with the equipment consumption cost (Appendix A).

4.3.1 Oil fuel and Energy consumption

The over all of the construction project consumed oil fuel 97,695.19 litres with the electricity consumption 2,080,708.26 kw. The data was gathered from the construction equipments that consume the oil fuel and electricity consumption in Structural Activities 97,394.69 litres with 886,518.88 kw, Architectural Activities 666,735.08 kw only and 300.5 litres with 527,454.30 kw of all System Activities as summarized the detail of each work in Figure 4.3 - 4.7. Some Sub-activites consumed both of oil fuel and electricity while some sub-activities consumed oil fuel or electricity either. (Appendix A)

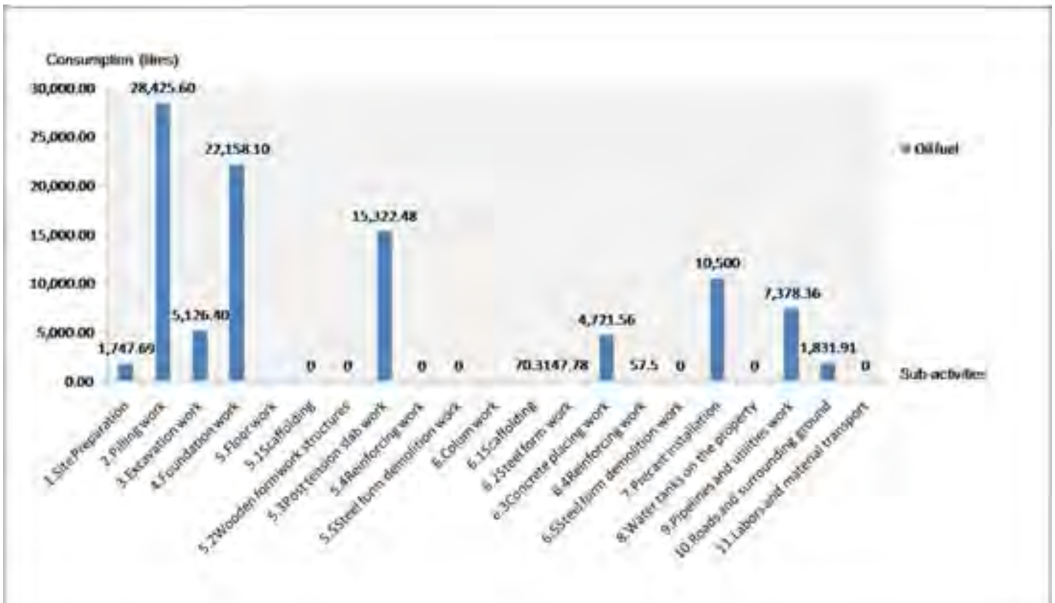

Figure 4.3: Oil fuel consumption in Structural Activities

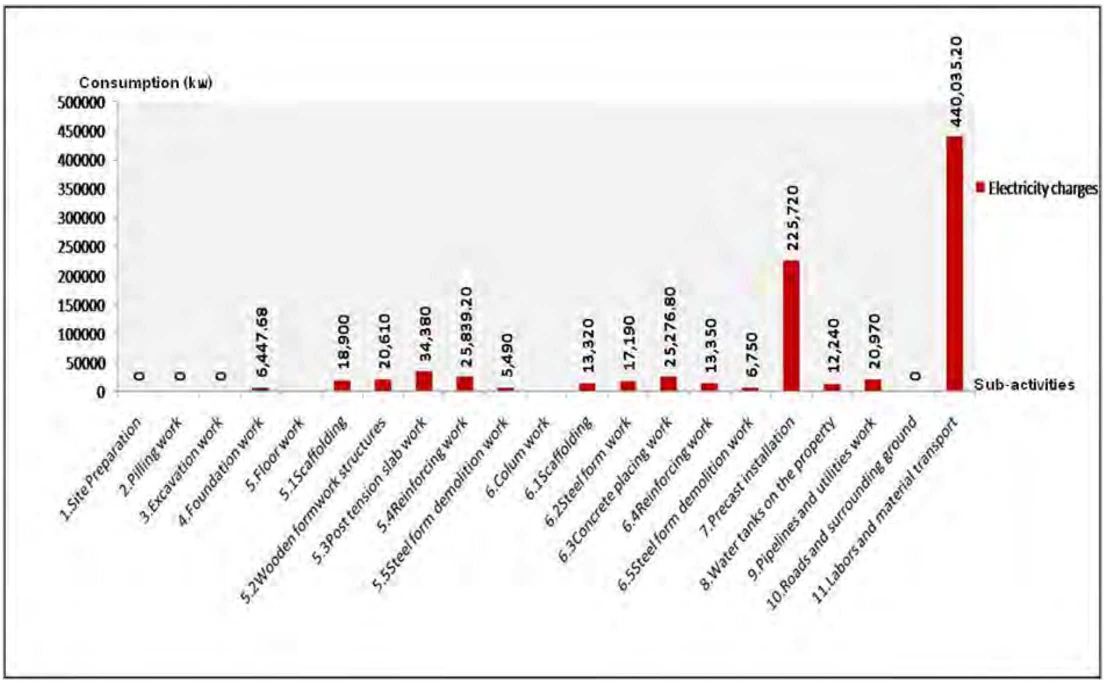

Figure 4.4: Electricity consumption in Structural Activities

The oil fuel and electricity consumption of Structural Activities were estimated in each sub-work of the activities. As the result shown that the most three of sub-work that to consumed oil fuel and electricity are shown as follows:

Oil fuel consumption;

1. Pilling work consumed oil fuel is 28,425.6 litres
2. Foundation work consumed oil fuel is 22,158.1 litres
3. Post tension slab work consumed oil fuel is 15,322.48 litres

Electricity consumption;

1. Labor and material transport consumed electricity is 440,035.2 Kw.
2. Precast installation consumed electricity is 225,720 Kw.
3. Post tension slab work consumed electricity is 34,380 Kw.

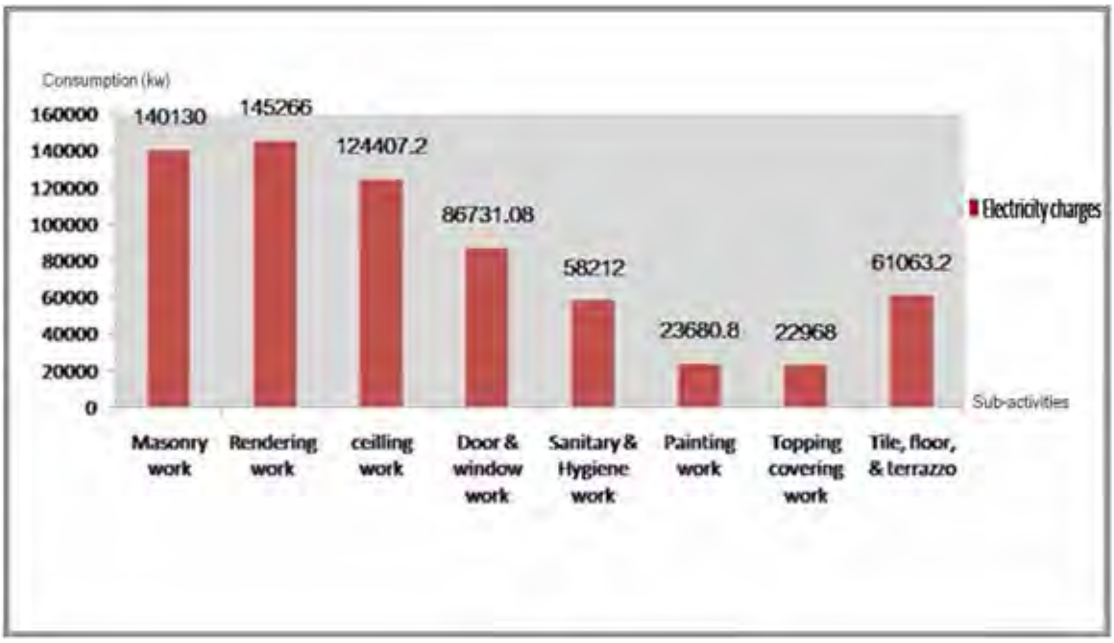

Figure 4.5: Electricity consumption in Architectural Activities

For Architectural Activities, most of construction equipment just only used electricity consumption as resource to finish the work whiles the oil fuel construction equipment not used at all because most of work are the only setting or installation and transport the construction materials and components to the high floor level of building. Most of sub-work focusing on transport the material from ground level to the upper level by using site elevator and tower crane, cutting, welding, and drilling. As the result of consumption rate from Architectural Activities shown that the most three of sub-work consumed electricity is shown as follows;

Electricity consumption;

1. Rendering work consumed electricity is 145,266 Kw.
2. Masonry work consumed electricity is 140,130 Kw.
3. Ceiling work consumed electricity is 124,407.20 Kw.

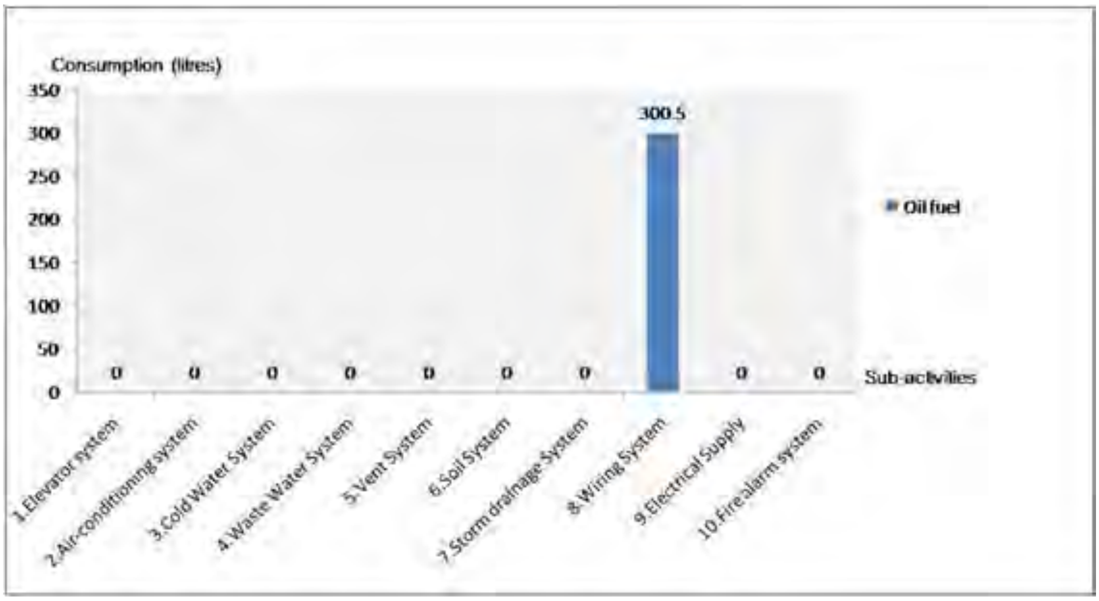

Figure 4.6: Oil fuel consumption in System Activities

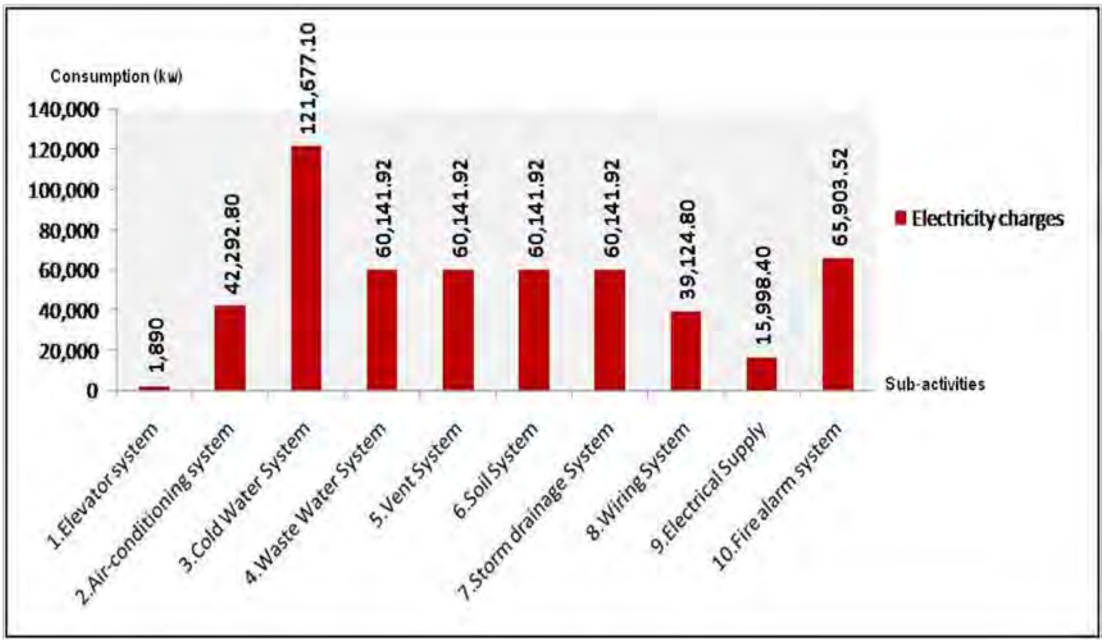

Figure 4.7: Electricity consumption in System Activities

As the results of consumption rate from System Activities in Figure 4.6 – 4.7, the activities just used the type of construction equipment as same as Architectural Activities by using electricity consumption because most of process in sub-activities just setting, installing, welding and transport the material excepted the Wiring system that to consumed a few of oil fuel. In case of transport material, the Architectural and System

Activities will estimated include in Structural Activities. Then, the most three of sub-activities that to consumed oil fuel and electricity are shown as follows:

Oil fuel consumption;

1. Wiring system consumed oil fuel is 300.5 litres

Electricity consumption

1. Cold water system consumed electricity is 121,677.1 Kw
2. Fire alarm system consumed electricity is 65,903.52 Kw
3. Waste water, Vent, Soil and Storm drainage system or as the sub-activities called Plumbing System consumed electricity the same as 60,141.92 kw of each.

4.3.2 CO_2 Emission Estimation at each Activity

The main sources of consumption in the construction project are oil fuel and electricity consumption. The research estimated CO_2 emission in each activities since the project began until completely around 22 months of construction phase time by using the data collection of quantity of equipment, working time of equipment, and during phase time in construction report. After that, estimate oil fuel and electricity consumption in this project and input to IPCC 2006 formula for identify the CO_2 emission, the detail of the quantity of CO_2 emission estimation at each activity shown in Table 4-6, 4-7 and 4-8.

Table 4-6 : CO_2 emission estimation in Structural Activities before applying Cleaner Technology.

FACTOR		Consumption		CO_2	Fuel Cost	Electricity Charges
No.	Activity	Oil fuel (litre)	Electricity (kw)	Total (kg)	Baht	Baht
1	Site Preparation	1,747.69	0.00	2,482.65	51,434.48	0.00
2	Pilling work	28,425.6	0.00	35,200.73	836,564	0.00
3	Excavation work	5,126.4	0.00	7,282.2	142,392.8	0.00
4	Foundation work	22,158.1	6,447.68	32,245.82	599,343.99	41,502.55
5	Floor work					
5.1	Scaffolding	0.00	18,900	10,602.96	0.00	121,657.41
5.2	Wooden formwork structure	0.00	20,610	11,562.21	0.00	132,664.51
5.3	Post tension slab work	15,322.48	34,380	41,053.24	458,862.7	221,301
5.4	Reinforcing work	0.00	25,839.2	14,495.79	0.00	166,324.35
5.5	Steel form demolition work	0.00	5,490	3,079.89	0.00	35,338.58
6	Colum work					
6.1	Scaffolding	70.31	13,320	7,572.39	2,069.19	85,740.87
6.2	Steel form work	47.78	17,190	9,211.46	1,406.15	11,0651
6.3	Concrete placing work	4,721.56	25,276.8	18,930.35	145,754.2	162,704.23
6.4	Reinforcing work	57.5	1,3350	8,247.22	551.81	85,932.62
6.5	Steel form demolition work	0.00	6,750	3,786.75	0.00	43,449.5
7	Precast installation	10,500	225,720	141,544.47	309,015	1,452,938
8	Water tanks on the property	0.00	12,240	6,866.64	0.00	78,787.56
9	Pipelines and utilities work	7,378.36	20,970	22,245.35	217,145	134,981.9
10	Roads and surrounding ground	1,831.91	0.00	2,602.31	55,337.54	0.00
11	Labors and material transport	0.00	440,035.2	246,859.8	0.00	2,832,643
12	$\sum$	**97,394.69**	**886,518.88**	**625,872.23**	**2,819,876.86**	**5,706,617.08**

Table 4-7 : CO_2 emission estimation in Architectural Activities before applying Cleaner Technology.

FACTOR		Consumption		CO_2	Fuel Cost	Electricity Charges
No.	Activity	Oil fuel (litre)	Electricity (kw)	Total (kg)	Baht	Baht
1	Masonry work	0.00	140,130	78,612.93	0.00	902,002.7
2	Rendering work	0.00	145,266	81,493.86	0.00	935,062.72
3	Ceiling work	0.00	124,407.2	69,792.33	0.00	800,896.1
4	Doors and windows work	0.00	86,731.08	48,656.14	0.00	558,278.1
5	Sanitary and hygiene fitting	0.00	58,212	32,656.93	0.00	374,704.82
6	Painting work	0.00	23,680.8	13,284.93	0.00	152,431.5
7	Topping covering work	0.00	27,244.8	15,284.33	0.00	175,372.05
8	Tile, floor and terrazzo work	0.00	61,063.2	34,256.46	0.00	393,056.5
9	$\sum$	0.00	666,735.08	373,137.911	0.00	4,291,804.49

Table 4-8 : CO_2 emission estimation in System Activities before applying Cleaner Technology.

FACTOR		Consumption		CO_2	Fuel Cost	Electricity Charges
No.	Activity	Oil fuel (litre)	Electricity (kw)	Total (kg)	Baht	Baht
1	Elevator system	0.00	1,890	1,060.29	0.00	12,165.74
2	Air-conditioning system	0.00	42,292.8	23,726.25	0.00	272,234.6
3	Cold Water System	0.00	121,677.1	68,260.85	0.00	783,223.33
4	Waste Water System	0.00	60,141.92	33,739.62	0.00	387,127.52
5	Vent System	0.00	60,141.92	33,739.62	0.00	387,127.52
6	Soil System	0.00	60,141.92	33,739.62	0.00	387,127.52
7	Storm drainage System	0.00	60,141.92	33,739.62	0.00	387,127.52
8	Wiring System	300.5	39,124.8	22,375.89	8,843.68	251,841.1
9	Electrical Supply	0.00	15,998.4	8,975.1	0.00	102,979.7
10	Fire alarm system	0.00	65,903.52	36,971.88	0.00	424,214.37
11	$\sum$	300.5	527,454.3	296,328.77	8,843.68	3,395,169

In case of Structural Activities, the activities released more CO_2 when compared another results. In deeply, Structural Activities is composed more sub-activities to consisting the building especially when observed the results in Figure 4.8 that the most three of sub-work that to emitted the CO_2 are shown as:

1. Labors and Materials transport emitted the CO_2 is 246.86 ton-CO_2. The definitions of these sub-works just means site elevator to transport or moving the construction material, construction equipments and labors between floors since the beginning of the project until completely. Then, these activities just only consumed electricity.

2. Precast installation emitted the CO_2 is 141.54 ton-CO_2. The sub-works started to emitted the CO_2 by transported the precast sheet with trailer (5 sheets per truck) from the factory to site construction project with distance around 50 Km. (rounds to 100 Km.). When the precast sheets arrived in construction site project, the Tower crane lifting up the precast sheet to upper floor for installed to building.

3. Post tension slab work of Floor Work emitted the CO_2 is 41.05 ton-CO_2. These sub-works consumed the oil fuel and electricity as sources to moving and installed the post tension slab of Floor Work as floor by floor.

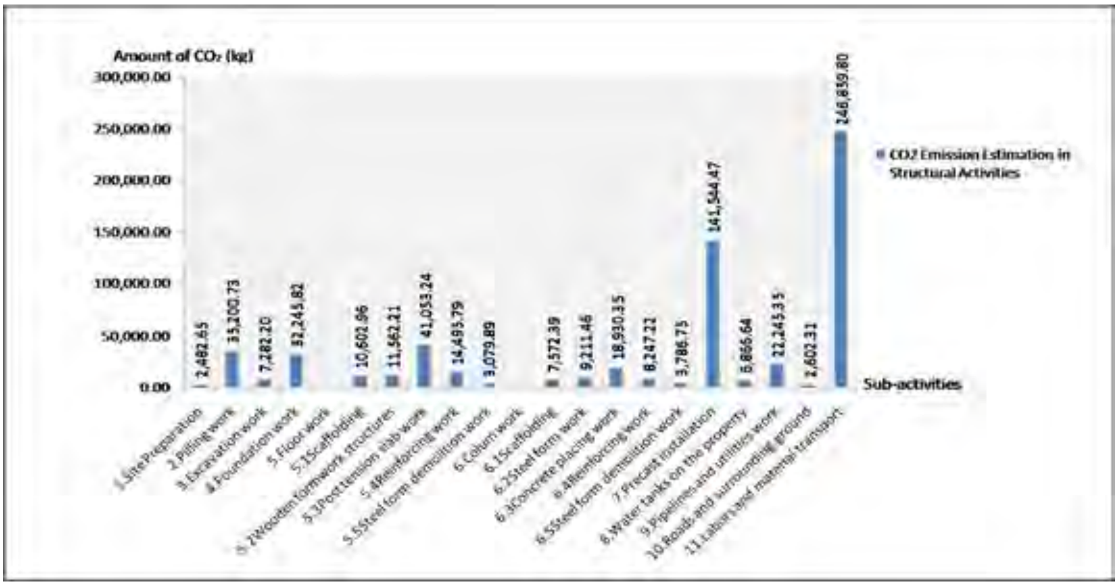

Figure 4.8: CO_2 emission estimation in Structural Activities

For Architectural Activities, most of the sub-work used tower crane to moving the construction material from ground to the upper floor such as cement packs, ceiling, doors and windows components, sanitary ware, color for painting, lightweight bricks and some handle construction equipments which just consumed only electricity as sources to composing the materials. The Figure 4.9 showed the estimations of CO_2 emission as:

1. Rendering work is the highest sub-work in Architectural Activities emitted the CO_2 by 81.49 ton-CO_2.

2. Masonry work is the second sub-work work in Architectural Activities emitted the CO_2 by 78.61 ton-CO_2.

3. Ceiling work is the third sub-work work in Architectural Activities emitted the CO_2 by 69.79 ton-CO_2.

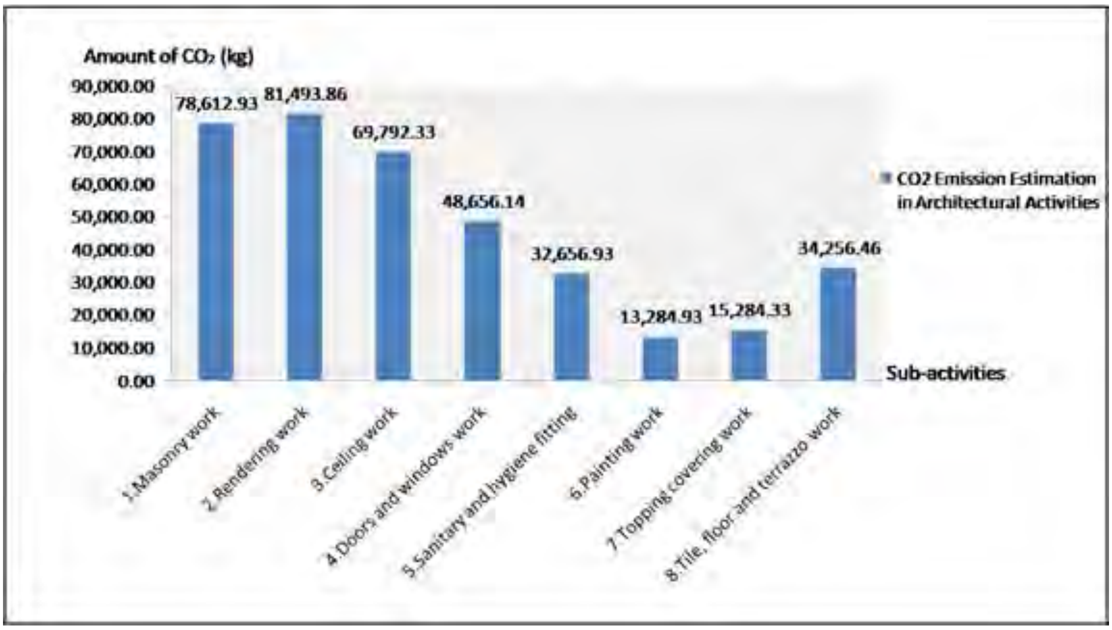

Figure 4.9: CO_2 emission estimation in Architectural Activities

In case of System Activities, these activities response about setting up the implement system of the building with the construction equipments which consumed the electrical power as sources such as tower crane, electrical welding, rotary drilling, cutting steel machines, PVC welding and demolition hammer. The Figure 4.10 showed the results of CO_2 emission as follow that:

1. Cold water system is the most sub-work to emitted the CO_2 emission is 68.26 ton-CO_2.

2. Fire alarm system emitted the CO_2 emission is 36.97 ton-CO_2

3. Plumbing system which composed Waste water system, Vent system, Soil system and Storm drainage system is 33.73 ton-CO_2 of each

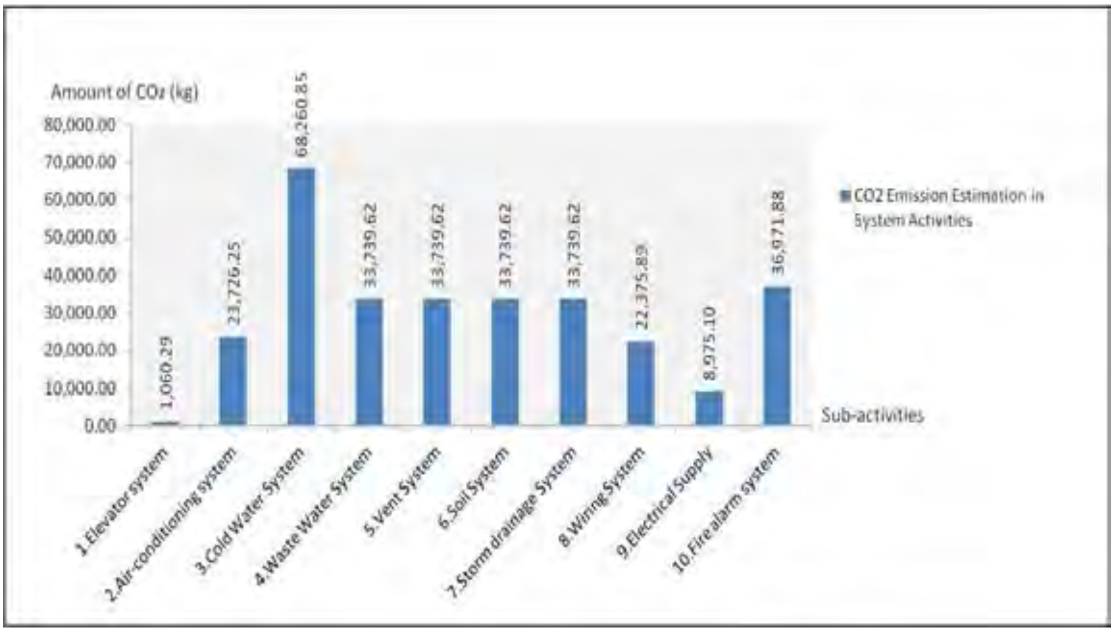

Figure 4.10: CO_2 emission estimation in System Activities

4.3.3 CO_2 Emission Estimation from Heavy Construction Equipments.

From the result of CO_2 emission estimation, the research was estimated the result from overall activities for identified the CO_2 emission in each construction equipments (Appendix B). The most of construction equipment that to emitted the CO_2 is Tower crane (742,503.76 kg-CO_2 or 742.50 ton-CO_2) and Dump truck is emitted lowest CO_2 in the project (27.97 kg-CO_2 or 0.028 ton-CO_2) as summarize in the Table4-9.

Table 4-9 CO_2 emission from heavy construction equipments

Construction Equipments	CO_2 Emission (kg)
1. Tower crane	742,503.76
2. Site elevator	473,516.44
3. Excavator (Back hoe)	39,192.99

4. Generator	27,390.10
5. Concrete truck	21,935.37
6. Trailer	14,715.55
7. Mobile concrete pump	8,163.43
8. Drilling rig crane	5,029.68
9. Mobile crane	4,827.53
10. Rolling compactor	1,022.78
11. Truck with crane	256.21
12. Dump truck	27.97

4.4 Cleaner Technology Application in Construction Activity

Before using the application, the Cleaner Technology were presented a guideline to the owner, construction team project which composed project's manager, project's engineer, site engineer and contractor for understanding the benefits and get the collaboration with all construction team member until project completely.

The application divided the method to reduce the CO_2 emission in construction to 2 methods;

1. The direct method could display the explicit result directly such as

1.1 Stop the engine of the machine every time whenever the machines are not used in the work.

1.2 Checking and Maintenance of the machine before the high-rise building project begins

1.3 Changing the size of concrete truck to reduce a quantity of concrete truck.

1.4 Selecting a concrete plant nearly the site project or use a concrete plant on-site in the project for reduce transportation distance and oil fuel cost.

1.5 For the construction material transport, must check the tires of truck to ensure that the tires fully inflated for reduce oil fuel and save cost.

2. For indirect method, gave the uncertain results depending on many factors such as

2.1 Changing the employee's behaviors in the construction organization because most of them has a little of environment impact then the company should be providing, supporting some knowledge and negotiation with employee to approach the reduction of CO_2 emission.

2.2 Planning for evident work procedures and sequencing of construction equipments for saving the construction time and oil fuel and electricity consumption.

2.3 Improving the preventive program of the construction equipment by setting out the policy of company.

2.4 Using the site elevator management by setting the schedule to use and limit the lowest floor level that could be used the site elevator. Moreover, control the weight or volume of the materials lifting to the upper floor.

2.5 Using the properly construction equipments with the manner and the right skills of work.

Finally, Cleaner Technology could help the owner of construction business in term of reducing the investment and construction cost such as oil fuel and electricity cost. Beside that Cleaner Technology would enhance the good image and marketing of the company.

The Figure 4.11 and Figure 4.12 shown the oil fuel and electricity consumption of Structural Activities after applying Cleaner Technology in each sub-activities, the result shown that Cleaner Technology could reduce the consumption of those efficiency by the most three of sub-activities that to consumed oil fuel and electricity before applying Cleaner Technology are shown as follows:

Oil fuel consumption;

1. Pilling work consumed oil fuel is 18,773.7 litres
2. Foundation work consumed oil fuel is 15,868.44 litres
3. Post tension slab work consumed oil fuel is 13,219.10 litres

Electricity consumption;

1. Labor and material transport consumed electricity is 266,588.2 Kw.

2. Precast installation consumed electricity is 212,918.76 Kw.

3. Post tension slab work consumed electricity is 17,640 Kw.

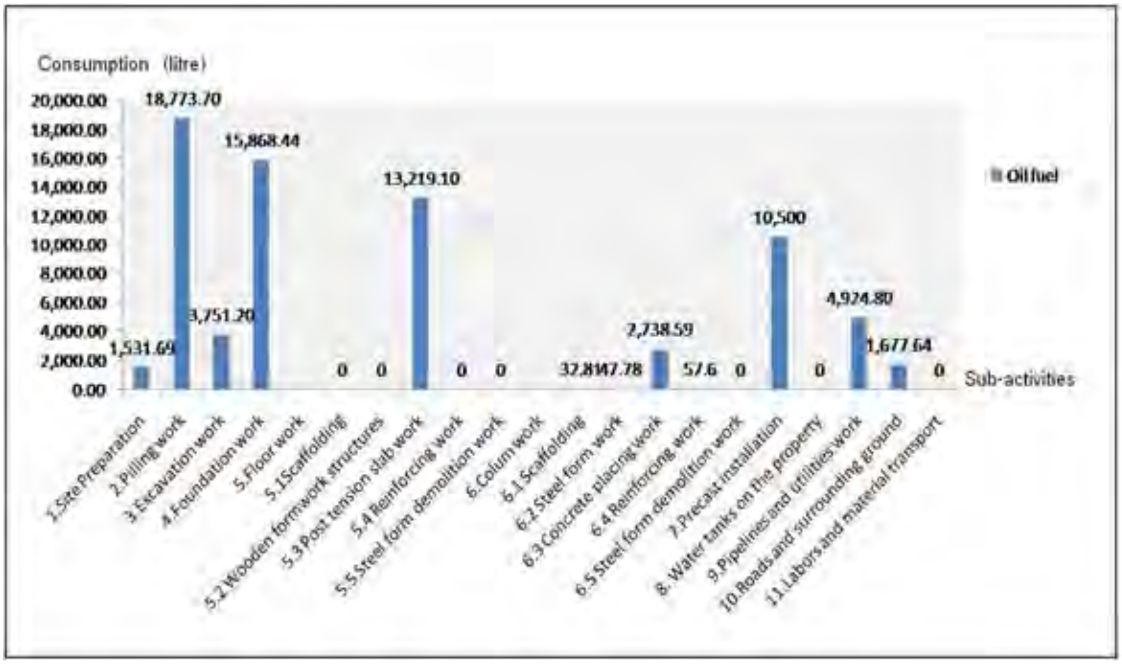

Figure 4.11: Oil fuel consumption in Structural Activities estimation after Cleaner Technology application

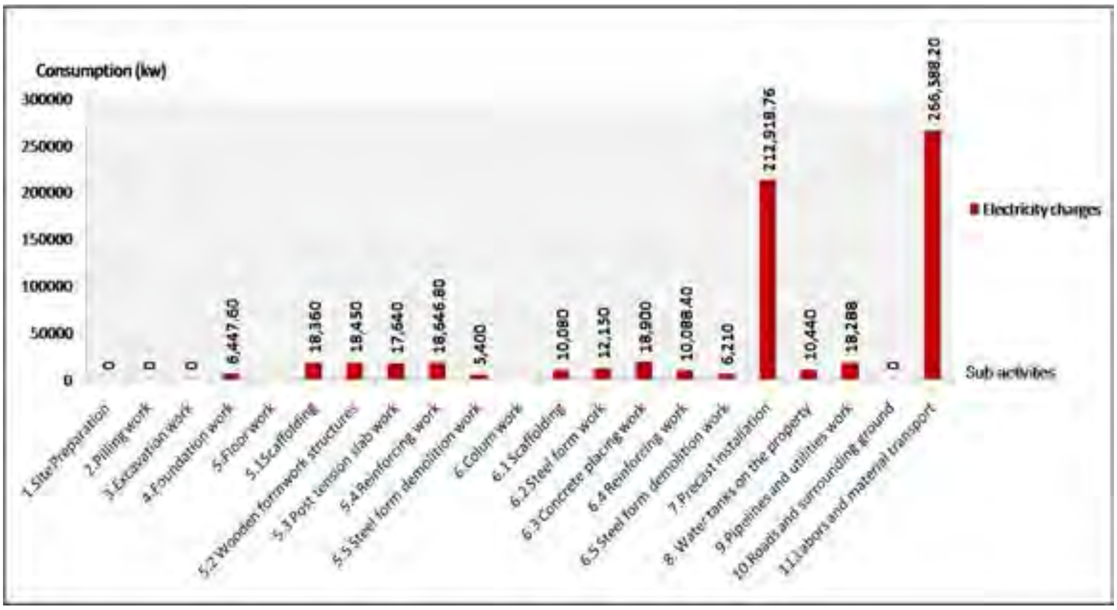

Figure 4.12: Electricity consumption in Structural Activities estimation after Cleaner Technology application

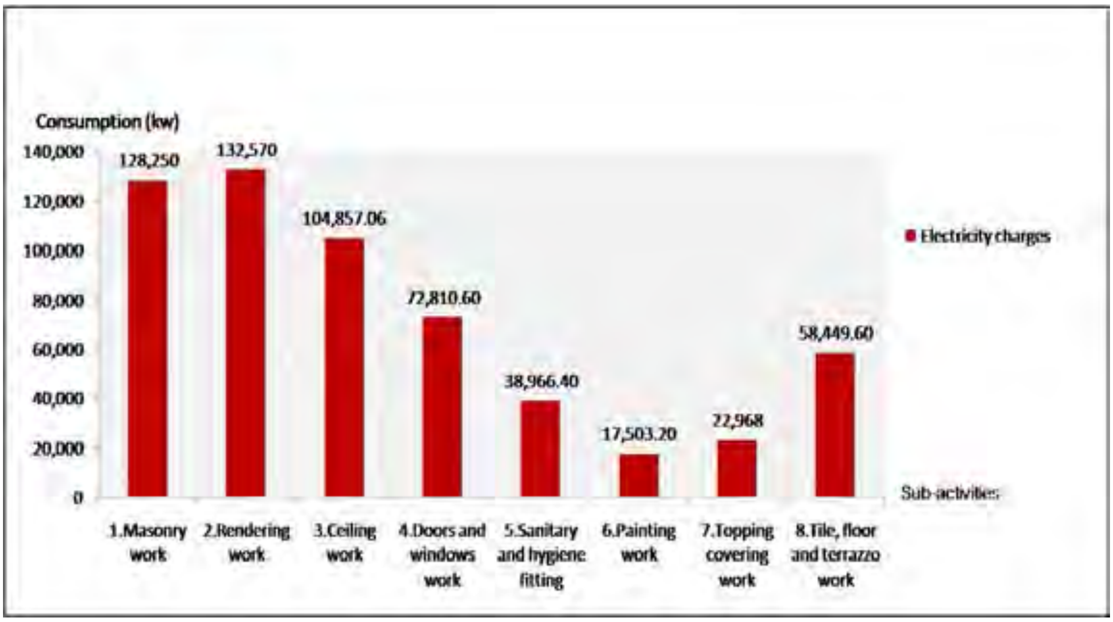

Figure 4.13: Electricity consumption in Architectural Activities estimation after Cleaner Technology application

For Architectural Activities, the most of consumption rate decreasing because the activities are under controlled and managing the sequence of construction process. Moreover, the project engineer was changing the properly right equipment to the right work. The Figure 4.13 shown that the most three of sub-work that to consumed electricity before applying Cleaner Technology could reduce as follows;

Electricity consumption;

1. Rendering work consumed electricity is 132,570 Kw.
2. Masonry work consumed electricity is 128,250 Kw.
3. Ceiling work consumed electricity is 104,857.06 Kw.

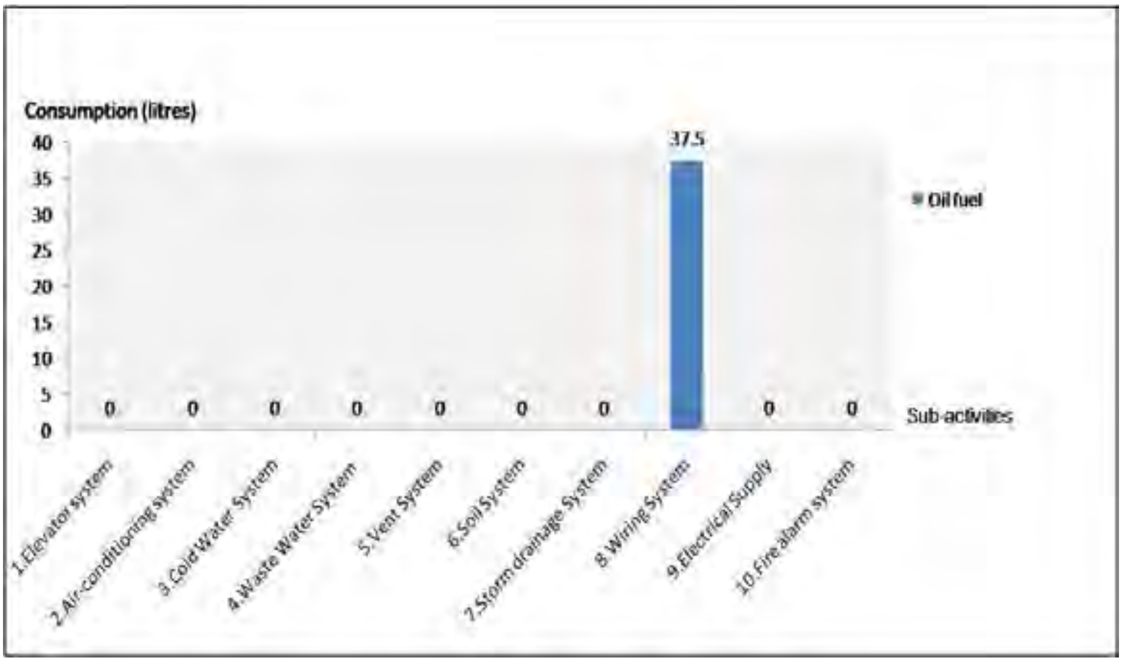

Figure 4.14: Oil fuel consumption in System Activities estimation after Cleaner Technology application

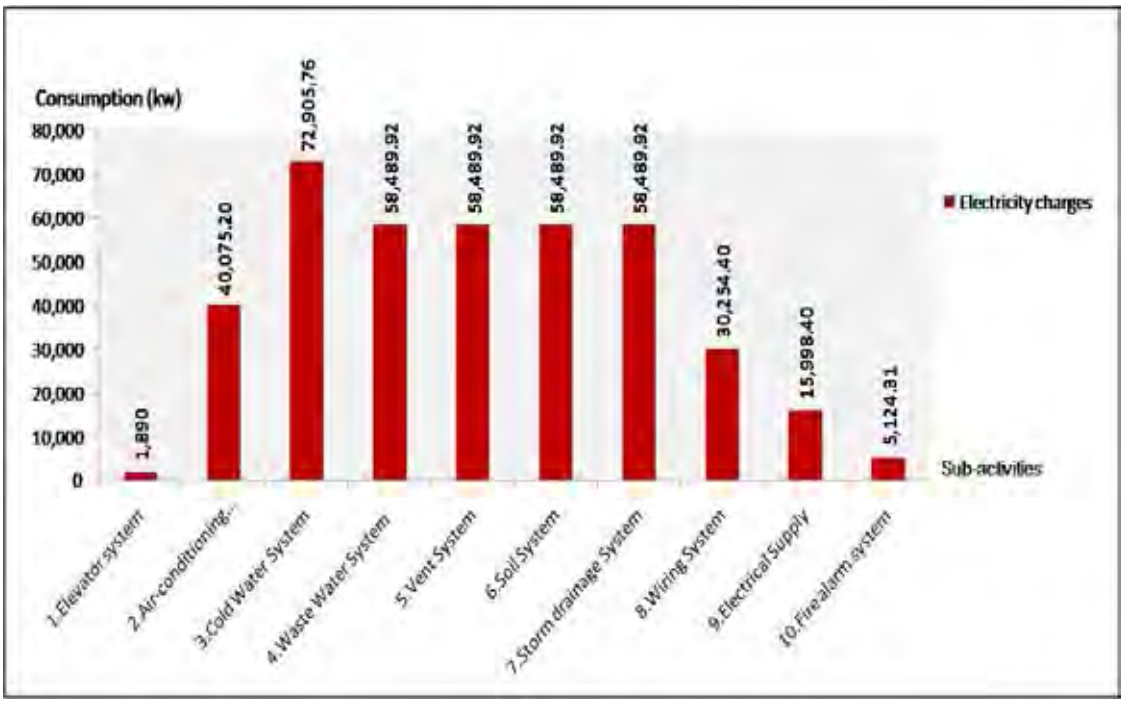

Figure 4.15: Electricity consumption in System Activities estimation after Cleaner Technology application

As the results of consumption rate after Cleaner Application from System Activities in Figure 4.14 – 4.15, the activities also could reduction the consumption. Then, the most three of sub-activities that to consumed oil fuel and electricity before applying Cleaner Technology as follows:

Oil fuel consumption;

1. Wiring system consumed oil fuel is 37.5 litres

Electricity consumption

1. Cold water system consumed electricity is 72,905.76 Kw

2. Fire alarm system consumed electricity is 5,124.31 Kw

3. Waste water, Vent, Soil and Storm drainage system or as the sub-activites called Plumbing System consumed electricity the same as 58,489.92 kw.

4.4.1 CO_2 Emission Estimation after Cleaner Technology application

When applied Cleaner Technology in Structural Activities with the strong management to reduction the CO_2 Emission shown as Figure 4.16

1. Labors and Materials transport emitted the CO_2 from 246.86 ton-CO_2 to 149.55 ton-CO_2 or could be reduce 97.31 ton-CO_2.

2. Precast installation emitted the CO_2 from 141.54 ton-CO_2 to 134.36 ton-CO_2 or could be reduce 7.18 ton-CO_2.

3. Post tension slab work of Floor Work emitted the CO_2 41.05 ton-CO_2 to 28.67 ton-CO_2 or could be reduce 12.38 ton-CO_2.

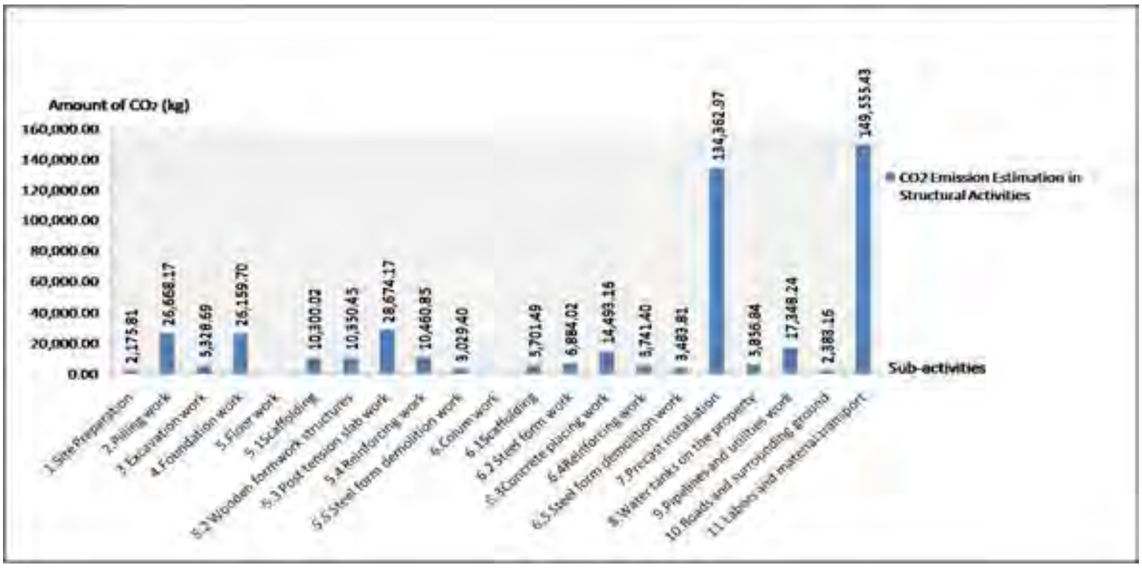

Figure 4.16 : CO_2 emission estimation in Structural Activities after Cleaner Technology application.

For Architectural Activities, when applied Cleaner Technology to the activities that the application could reduce the CO_2 emission efficiently especially most sub-activities which is emitted CO_2 emission;

1. Rendering work emitted the CO_2 from 81.49 ton-CO_2 to 74.37 ton-CO_2 or could be reduce 7.12 ton-CO_2.

2. Masonry work emitted the CO_2 from 78.61 ton-CO_2 to 71.95 ton-CO_2 or could be reduce 6.66 ton-CO_2.

3. Ceiling work emitted the CO_2 from 69.79 ton-CO_2 to 58.82 ton-CO_2 or could be reduce 10.97 ton-CO_2. .

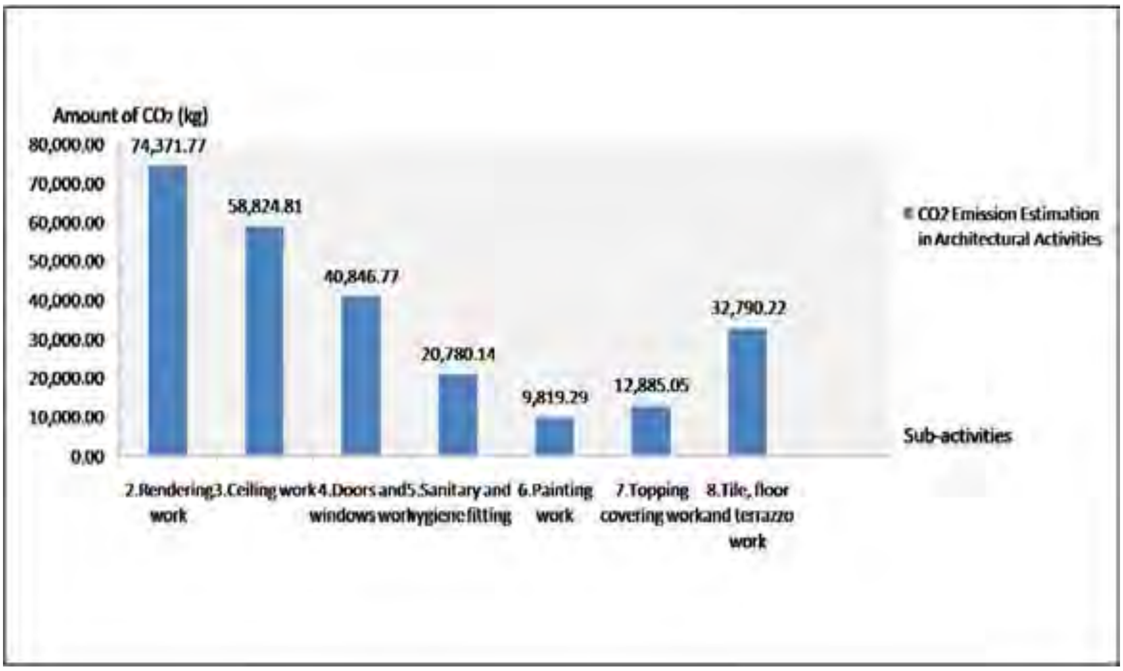

Figure 4.17 : CO_2 emission estimation in Architectural Activities after Cleaner Technology application.

In such case of System Activities, The Figure 4.18 shown that the Cleaner Technology application also reduce the CO_2 emission of all sub-activities especially the three most sub-activities emitted as;

1. Cold water system, the sub-activities reduce the CO_2 emission from 68.26 ton-CO_2 to 40.90 ton-CO_2 or could be decreasing 27.36 ton-CO_2. .

2. Plumbing system which composed 4 sub-activities as Waste water system, Vent system, Soil system and Storm drainage system reduce the CO_2 emission from 33.74 ton-CO_2 to 32.81 ton-CO_2 or could be slightly decreasing 0.93 ton-CO_2 of each

3. Fire alarm system emitted the CO_2 emission from 36.97 ton-CO_2 to 25.72 ton-CO_2 or could be decreasing 11.25 ton-CO_2.

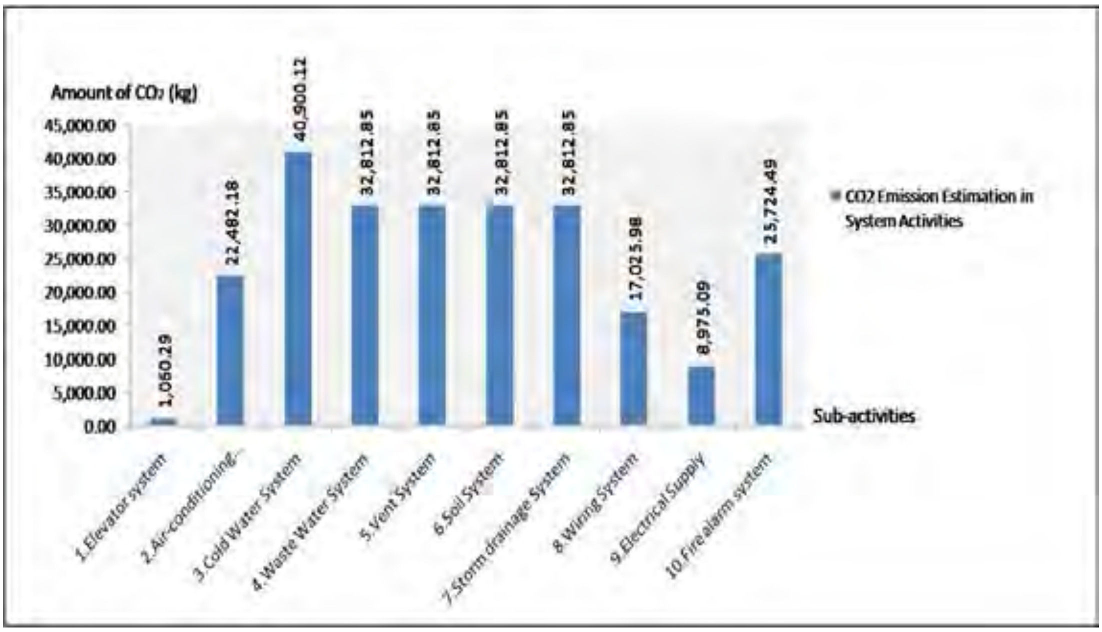

Figure 4.18 : CO_2 emission estimation in System Activities after Cleaner Technology application.

When we compare the results estimation of CO_2 emission in actual before and after simulate applied Cleaner Technology as shown in Figure 4.19 - 4.21 in each Activities, the Cleaner Technology could be applied to the construction project for reduce the CO_2 emission but depend upon the management since the construction project planning to construction phase times, the good practically with the rules at the project site. Some sub-activities could a few reducing the CO_2 emission by the reasons of construction materials purchasing and construction techniques.

Finally, the Figure 4.22 shown the summarize the comparison of the results the overall project with three main activities by following;

1. The estimation of CO_2 emission in Structural Activities before using Cleaner Technology is 625.87 ton-CO_2, but the Cleaner Technology could decreasing to 468.96 ton-CO_2 or 156.91 ton-CO_2 reduction (12.11% reduction of the overall project).

2. The Architectural Activities could decrease the CO_2 emission from 373.14 ton-CO_2 to 322.27 ton-CO_2 or 50.87 ton-CO_2 reduction (3.92% reduction of the overall project).

3. Cleaner Technology could reduce the CO_2 emission in System Activities from 296 .33 ton-CO_2 to 247.42 ton-CO_2 or 48.91 ton-CO_2 reductions (19.10% reduction of the overall project.)

4. The overview of this project emitted the CO_2 emission 1,295.34 ton-CO_2, but Cleaner Technology application could reduce to 1,038.64 ton-CO_2 or 256.7 ton-CO_2 reduction (19.82% reduction of the overall project)

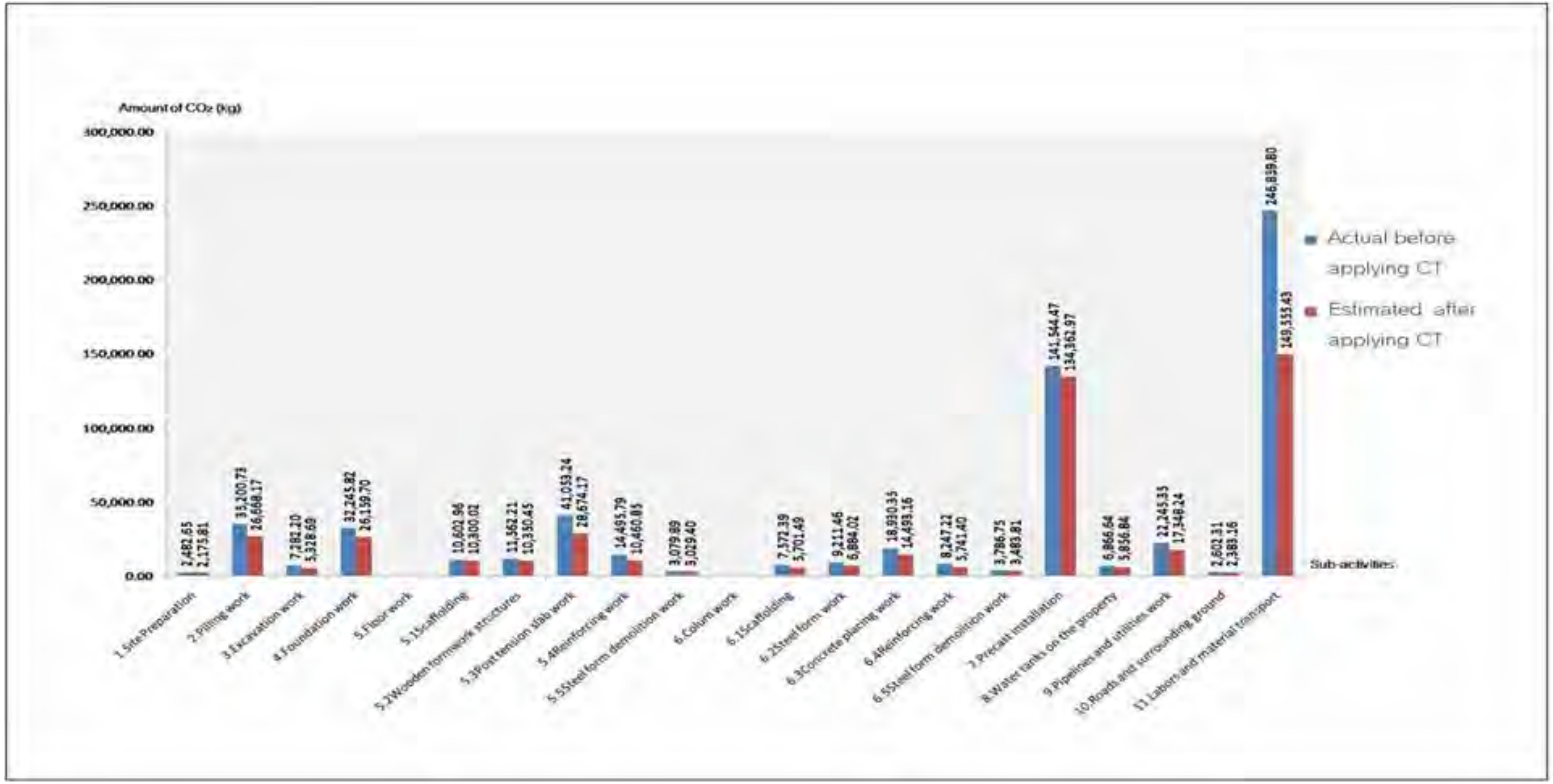

Figure 4.19 : Comparison the amount of CO_2 emission estimation of before and after applying Cleaner Technology in Structural Activities.

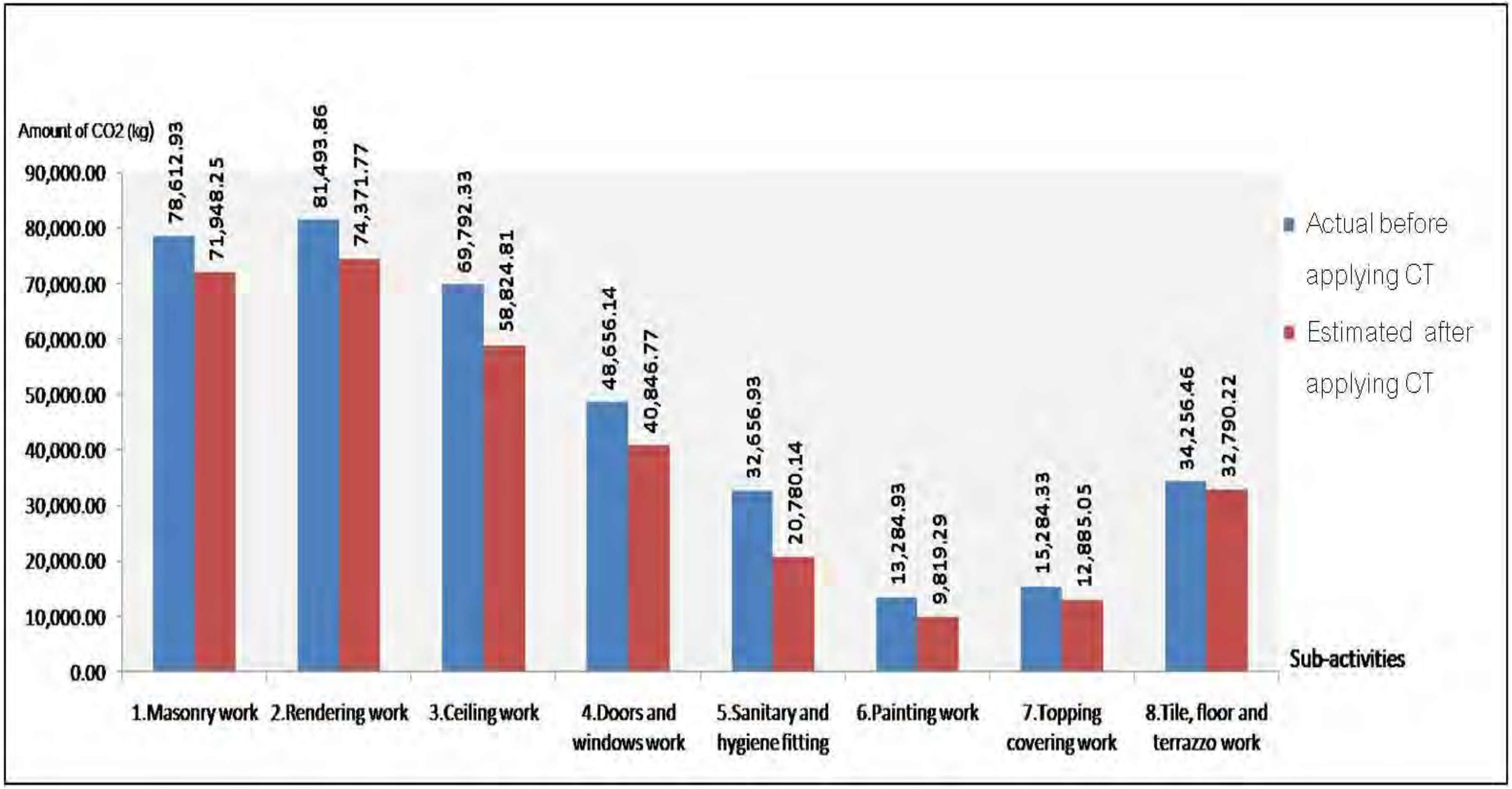

Figure 4.20 : Comparison the amount of CO_2 emission estimation before and after Cleaner Technology application in Architectural Activities.

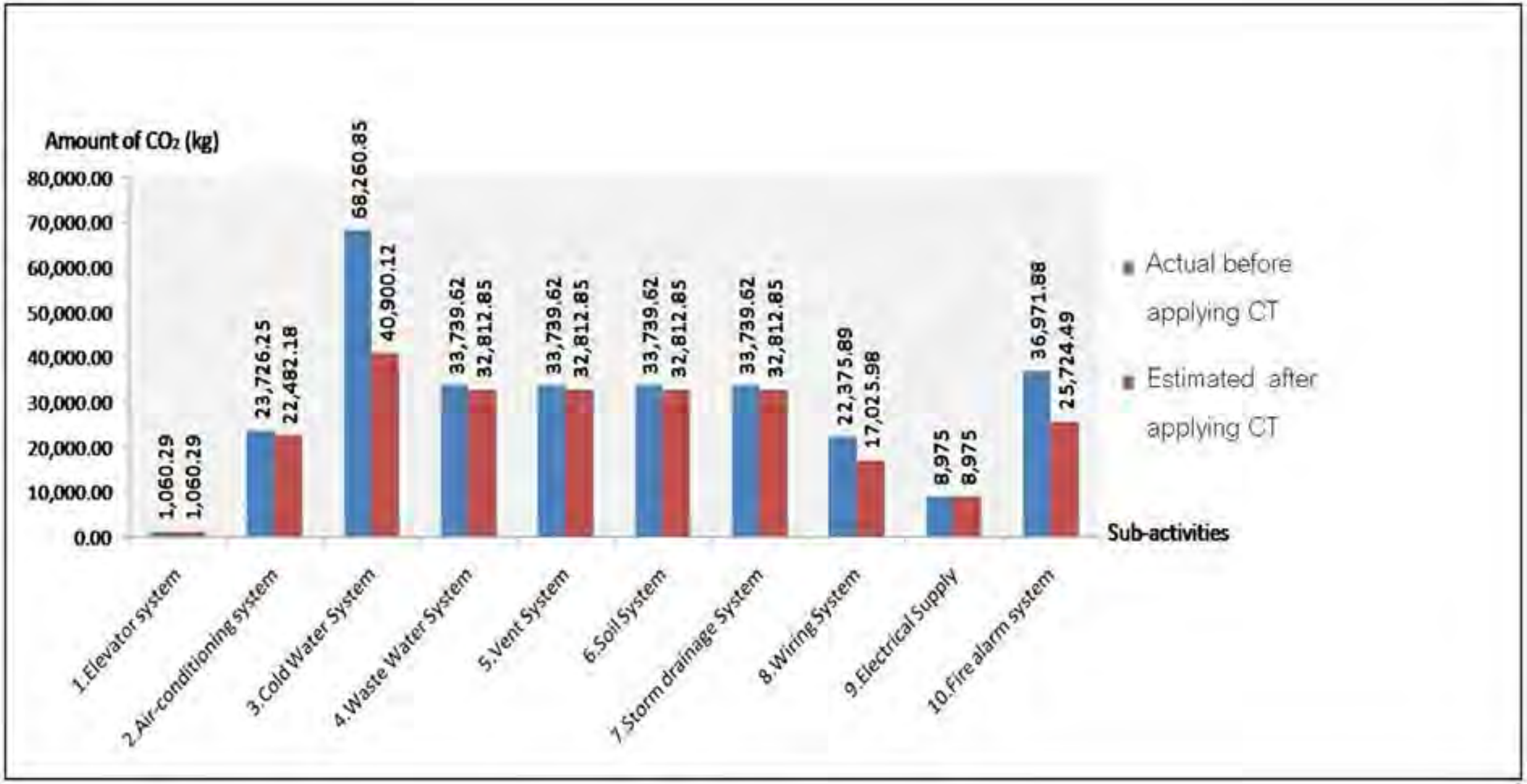

Figure 4.21 : Comparison the amount of CO_2 emission estimation before and after Cleaner Technology application in System Activities

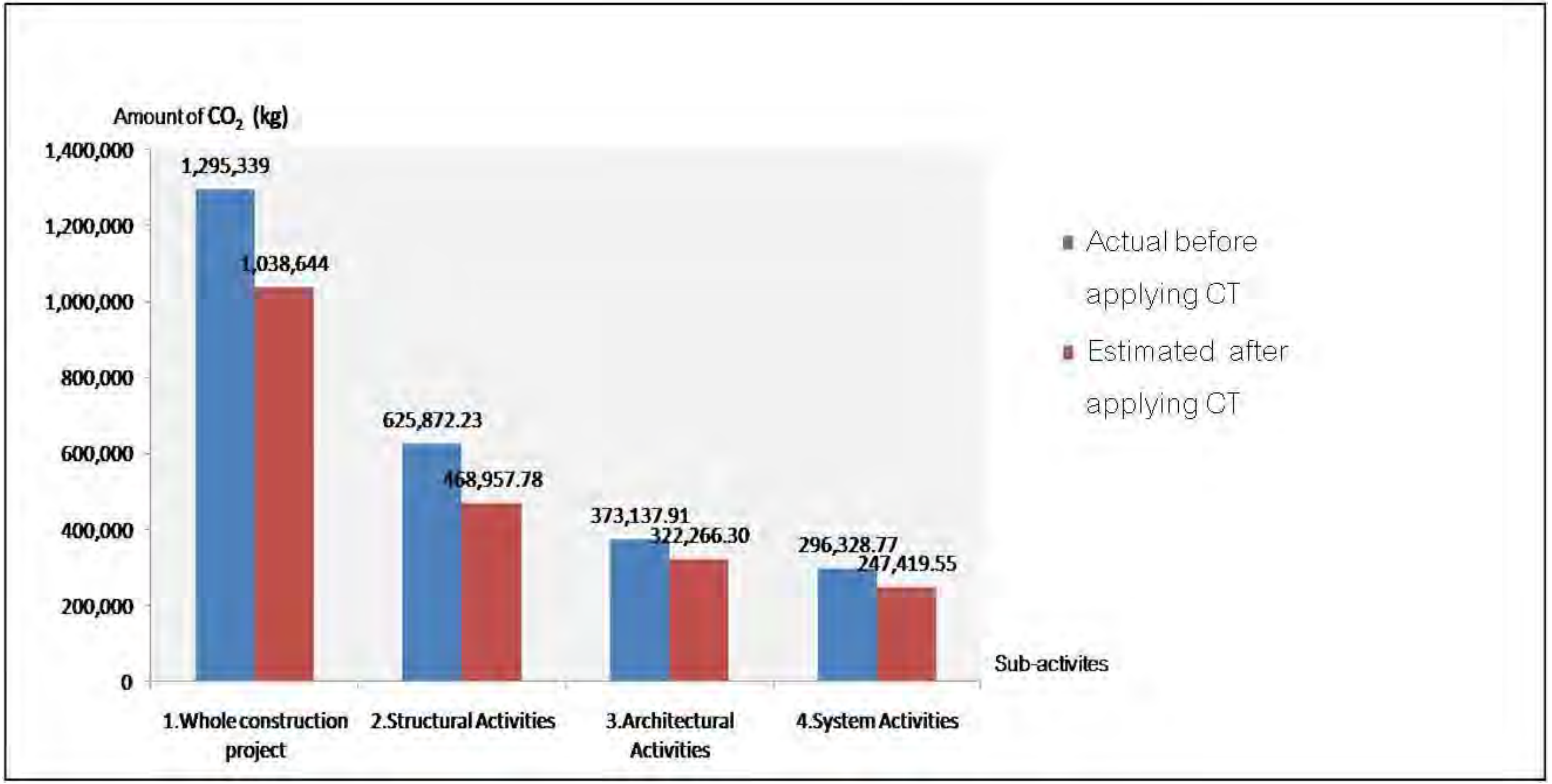

Figure 4.22 : Comparison the amount of CO_2 emission estimation before and after Cleaner Technology application in the all project

Table 4-10 : Comparison the estimation consumption cost before and after Cleaner Technology application

Activity	Actual Before CT Application		Estimated After CT Application		Reduction the cost of consumption	
	Oil fuel (Baht)	Electricity charges (Baht)	Oil fuel (Baht)	Electricity charges (Baht)	Oil fuel (Baht)	Electricity charges (Baht)
1. Structural	2,819,876.86	5,706,617.08	1,975,261.86	4,187,633.18	844,615.00	1,518,983.90
2. Architectural	0.00	4,291,804.49	0.00	3,710,140.57	0.00	581,663.92
3. System	8,843.68	3,395,171.00	1,103.62	2,576,097.00	7,740.06	556,896.35
Total	2,828,720.54	13,393,592.57	1,976,365.48	10,736,048.40	852,355.06	2,657,544.17
Overall project	16,222,313.11 Baht		12,712,413.88 Baht		3,509,899.23 Baht	

The estimation of the cost that used an average price of oil fuel unit in 2011 at 29.43 Baht per litre of PTT Company and electricity charges unit cost in type 8 at rate 6.4369 Baht per unit. Then, the Cleaner Technology can reduce cost of oil fuel and electricity consumption 3,509,899.23 Baht from the total cost of oil fuel and electrical charges 16,222,313.11 Baht or 21.64%

4.4.2 CO_2 Emission Estimation from Heavy Construction Equipments after Cleaner Technology application.

From the result of CO_2 emission estimation from main heavy construction equipments, the most of construction equipment could reduction emission the CO_2 especially Tower crane (421,036.11kg-CO_2 or 421.04 ton-CO_2) and Dump truck is the construction equipment that to emitted lowest CO_2 in the project (27.97 kg-CO_2 or 0.028 ton-CO_2) as summarize in the Table4-8 (Appendix C).

Table 4-11 CO_2 emission from heavy construction equipments after Cleaner Technology application

Construction Equipments	CO_2 Emission Estimation (kg-CO_2)		
	Actual Before CT Application	Estimated After CT Application	Reduction
1. Tower crane	742,503.76	421,036.11	321,467.65
2. Site elevator	473,516.44	384,996.32	88,520.12
3. Excavator (Back hoe)	39,192.99	28,167.43	11,025.56
4. Generator	27,390.10	20,542.56	6,847.54
5. Concrete truck	21,935.37	16,577.59	5,357.78
6. Trailer	14,715.55	14,715.55	0.00
7. Concrete mobile pump	8,846.71	8,163.43	683.28
8. Drilling rig crane	5,029.68	4,069.82	959.86
9. Mobile crane	4,827.53	3,589.96	1,237.57
10. Rolling compactor	1022.78	835.27	187.51
11. Truck with crane	256.21	249.56	6.65
12. Dump truck	27.97	27.97	0.00
$\sum$	1,339,265.09	902,971.57	436,293.52

CHAPTER V

CONCLUSION AND RECOMENDATION

The high-rise building construction process creates a wide range of environmental effects especially greenhouse gas. Cleaner Technology is the one tools or principal applying in construction project because the principal just using observing, surveying, improving, monitoring and assessments the process of construction activities without any cost. This chapter aims to summarize the efficiency of Cleaner Technology whenever applied to the construction project and suggestion.

5.1 CO_2 Emission Estimation of The Project.

5.1.1 In the high-rise building construction project found that the most activities that to emitted the CO_2 is Structural Activities 625,872.23 kg-CO_2 or 48.31% of all activities, Architectural Activities 373,137.911 kg-CO_2 or 28.81% of the entire project and 296,328.77 kg-CO_2 or 22.88% in System Activities

5.1.2 In case of heavy construction equipment found that most construction equipment is emitted CO_2 by arrangement the quantity of CO_2 5 type are Tower crane (742.50 ton-CO_2), Site elevator (473.52 ton-CO_2) ,Excavator (39.19 ton-CO_2), Generator (27.39 ton-CO_2), and Concrete truck (21.94 ton-CO_2).

5.1.3 The estimation of total CO_2 emission of overall is 1,295,338.91 kg-CO_2 or 57.43 Kg-CO_2 per m^2 of the construction project area 22,556.26 m^2.

5.1.4 The high-rise building construction project is used the cost of oil fuel and electricity charges 16,222,313.11 Bath; separated the total cost of oil fuel is 2,828,720.54 Bath or 17.44% with the total rate of electrical consumption is 13,393,592.57 Bath or 82.56% of the total cost of oil fuel and electrical consumption.

5.2 CO_2 Emission Estimation After Applying Cleaner Technology

5.2.1 As the results when simulate applying the Cleaner Technology that the CO_2 emission in Structural Activities decreasing from 625,872.23 kg-CO_2 to 468,957.78 kg-CO_2 or 12.11% reduction of the overall project, for Architectural Activities from 373,137.91 kg-CO_2 to 322,266.3 kg-CO_2 or 3.92% reduction of the overall project and 296,328.77 kg-CO_2 to 247,419.55 kg-CO_2 or 19.10% reduction of the overall project.

5.2.2 When simulate applying the Cleaner Technology into the construction project, the construction equipments also reduce the CO_2 emission by arrangement the quantity of CO_2 5 type as Tower crane (421.03 ton-CO_2), Site elevator (385ton-CO_2) ,Excavator (28.17 ton-CO_2), Generator (20.54 ton-CO_2), and Concrete truck (16.58 ton-CO_2).

5.2.3 The research found that Cleaner Technology can reduce the CO_2 Emission of overall the project from 1,295,210.87 kg-CO_2 to 1,016,348.21 kg-CO_2 or 45.06 kg-CO_2 / m^2 of the construction project area 22,556.26 m^2.

5.2.4 In the part of oil fuel and electrical consumption cost, Cleaner Technology can reduce the consumption cost in construction project from 16,222,313.11 Baht to 12,450,236.23 Baht by oil fuel cost decreasing to 852,355.06 Baht or 5.25% and could save electricity charges to 2,919,721.82 Baht or 18.00 %.

5.3 Limitation of Study

1. This research was estimated in overview of construction project then some activities might be occur the overlapping times of construction equipment, but also reducing the problem by good management and adjustment the data.

2. The important limitation of this study is the data collection because most of data is collected from construction report (daily report, weekly report and monthly report), some data were missing from report or not to recorded then the research must used the cooperation as interviewing, observing and estimating the engine consumption, working time of equipment and type of equipment by expert in the construction project then estimated the average rate of consumption equipment of the project.

3. The result of CO_2 emission is only estimated from IPCC Version 2006 formula, the value of the result is corrected or uncorrected depending on the input factor such as oil fuel and electricity consumption. If some data were uncorrected or inaccurate then will be influence to the result but not much.

4. The method that used for application of Cleaner Technology comes from observing, interviewing, consulting and suggestion of expert in the project. Some method could be applied to some part of construction activities but also some method when consults with the expert that is impossible to applied Cleaner Technology.

5.4 Recommendation for Further Research

This study focused only on estimation of CO_2 emission from the high-rise building construction epically the heavy construction equipment. Moreover, it is suggested that the further research can be applied on the any mega project such as dam, highway, subway, high speed train or infrastructure project.

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APPENDICES

APPENDIX A

Project Information from Data Collection

Table A.1 The project data collection for monthly record at 1 : January 25 - February 25, 2010.

January 25 - February 25, 2010 (31 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation	15	Back hoe	99	2	15	8	240		6	L/h	7.2	L/h	1728.00	L	2454.68	2482.64	4909.35	4965.29	50855.04	101710.08	0.00	0.00
		Dump truck	114	3	7	5	105	63	4	Km/L	3.2	Km/L	19.69	L	27.97		55.93		579.40	1158.81	0.00	0.00
2. Pilling work	31	Back hoe	99	2	31	8	496		6	L/h	7.2	L/h	3571.2	L	5073.00	18495.3	490935	17898.68	105100.42	101710.08	0.00	0.00
		Generator	60	1	31	8	248		19.5	L/h	23.4	L/h	5803.21	L	8243.62		7977.7		170788.18	165278.88	0.00	0.00
		Drilling rig crane		1	31	8	248		6.25	L/h	7.5	L/h	1860	L	2642.19		2556.95		54739.8	52974.00	0.00	0.00
		Mobile crane	169	1	31	8	248		6	L/h	7.2	L/h	1785.6	L	2536.5		2454.98		52550.21	50855.01	0.00	0.00
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		steel Cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.2 The project data collection for monthly record at 2 : February 26 - March 25, 2010.

February 26 - March 25, 2010 (28 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work	28	Back hoe	99	2	28	8	448		6	L/h	7.2	L/h	3225.60	L	4582.08	16705.43	4909.35	17898.68	94929.41	101710.08	0.00	0.00
		Generator	60	1	28	8	224		19.5	L/h	23.4	L/h	5241.60	L	7445.85		7977.70		154260.29	165278.88	0.00	0.00
		Drilling rig crane		1	28	8	224		6.25	L/h	7.5	L/h	1680.00	L	2386.49		2556.95		49442.40	52974.00	0.00	0.00
		Mobile crane	169	1	28	8	224		6	L/h	7.2	L/h	1612.80	L	2291.03		2454.68		47464.70	50855.04	0.00	0.00
3. Excavation work	10	Back hoe	99	2	10	8	160		6	L/h	7.2	L/h	1152.00	L	1636.45	1636.45	4909.35	4909.35	33903.36	101710.08	0.00	0.00
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.3 The project data collection for monthly record at 3 : March 26 - April 25, 2010.

March 26 - April 25, 2010 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	4	Back hoe	99	2	4	8	64		6	L/h	7.20	L/h	460.80	L	654.58	654.58	4909.35	4909.35	13561.34	101710.08		
4.Foundation	30	Back hoe	99	2	30	8	480		6	L/h	7.20	L/h	3456.00	L	4909.35		4909.35		101710.08	101710.08		
		Generator	60	1	30	8	240		19.5	L/h	23.40	L/h	5616.00	L	7977.70		7977.70		165278.88	165278.88		
		Tower crane											0.00	Kw.	0.00		0.00		0.00	0.00		
		Concrete truck	280	135	30	2	8100	4050	3	Km./L	2.40	Km./L	1687.50	L	2397.14	19345.32	2397.14	19345.32	49663.13	49663.13		
		Mobile pump	265	1	30	3	90		15.40	L/h	18.48	L/h	1663.20	L	2362.63		2362.63		48947.98	48947.98		
		Demolition hammer	1.05	2	15	5	150		1.05	Km./L	1.26	Km./L	189.00	Kw.	106.03		106.03		0.00	0.00	1216.57	1216.57
		Concrete vibrator	3.6	6	30	3	540		1.73	L/h	2.08	L/h	1121.04	L	1592.47		1592.47		38395.62	38395.62		
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding	3	Tower crane																				
		Truck with crane	92	1	3	4	12	60	4	Km./L	3.20	Km./L	18.75	L	26.63	26.63	266.35	266.35	551.81	5518.13		
6.2 Steel form work	2	Tower crane																				
		Truck with crane	92	1	2	4	8		4	Km./L	4.80	Km./L	38.40	L	54.55	54.55	818.23	818.23	1130.11	16951.68		
6.3 Concrete placing work	3	Tower crane																				
		Concrete truck	280	100	3	2	600	3000	3	Km./L	2.40	Km./L	1250.00	L	1775.66	2171.17	17756.63	21711.72	36787.50	367875.00		
		Mobile pump	265	1	3	3	9		15.4	L/h	18.48	L/h	166.32	L	238.26		2362.63		4894.80	48947.98		
		Concrete vibrator	3.6	6	3	3	54		1.73	L/h	2.08	L/h	112.10	L	159.25		1592.47		3839.56	38395.62		
6.4 Reinforcing work	3	Tower crane																				
		Truck with crane	92	1	3	4	12	60	4	Km./L	4.80	Km./L	57.60	L	81.82	130.29	818.23	1302.93	1695.17	16951.68		
		Steel cutting	2	2	3	6	36		2	Km./L	2.40	Km./L	86.40	Kw.	48.47		484.70					
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.4 The project data collection for monthly record at 4 : April 26 - May 25, 2010.

April 26 - May 25, 2010 (29 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation	14	Back hoe	99	2	14	8	224		6	L/h	7.20	L/h	1612.80	L	2291.03		4909.35		47464.70	101710.08		
		Generator	60	1	14	8	112		19.50	L/h	23.40	L/h	2620.80	L	3722.93		7977.70		77130.14	185278.88		
		Tower crane	75	1	14	4	56		75	Kw./h	90.00	Kw./h	5040.00	Kw.	2827.44		6058.80		0.00	0.00	32441.98	69518.52
		Concrete truck	280	63	14	2	1764	1890	3	Km./l	2.40	Km./l	787.50	L	1118.87	11555.81	2397.14	24762.44	23176.13	49663.13		
		Mobile pump	265	1	14	3	42		15.40	L/h	18.48	L/h	776.16	L	1102.56		2362.63		22842.39	48947.98		
		Demolition hammer	1.05	2	9	5	90		1.05	Km./h	1.26	Km./h	113.40	Kw.	63.62		136.32		0.00	0.00	729.94	1564.17
		Concrete vibrator	3.6	6	14	3	252		1	L/h	1.20	L/h	302.40	L	429.57		920.50		10357.20	22194.00		
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure	2	Tower crane	75	1	2	8	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84		12117.60				9269.14	139037.04
		Truck with crane																				
5.3 Post tension slab work	4	Tower crane	75	1	3	4	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88		4544.10				6951.85	52133.89
		Concrete truck	280	24	4	2	192	720	3	Km.l	2.40	Km./l	300.00	L	426.16	1244.37	3196.19	9332.76	8829.00	86217.50		
		Mobile pump															1592.47		5119.42	38395.62		
		Concrete vibrator	3.6	6	4	3	72		1.73	L/h	2.08	L/h	149.47	L	212.33							
5.4 Reinforcing work	2	Tower crane	75	1	2	6	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88		9088.20				6951.85	164277.78
		Truck with crane														648.96		9734.47				
		Steel cutting	2	2	2	8	32		2	Km./h	2.40	Km./h	76.80	Kw.	43.08		646.27				494.35	7415.31
5.5 Steel form demolition work	2	Tower crane	75	1	2	4	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92	403.9	6058.80	6058.80			4534.57	69518.52
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	1	4	2	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92	430.56	3029.40	3220.16			4634.67	34759.26
		Truck with crane	92	1	3	4	12	60	4	Km./l	3.20	Km./l	18.75	L	26.63		199.76		551.81	4138.59		
6.2 Steel form work	2	Tower crane														13.32		199.76				
		Truck with crane	92	1	2	8	16	30	4	Km./l	3.20	Km./l	9.38	L	13.32		199.76		275.91	4138.59		
6.3 Concrete placing work	3	Tower crane	75	1	16	3	48		75	Kw./h	90.00	Kw./h	4320.00	Kw.	2423.52		24235.20				27807.41	278074.08
		Concrete truck	280	11	3	2	66	330	3	Km./l	2.40	Km./l	137.50	L	195.32	2778.09	1953.23	27780.90	4046.63	40466.25		
		Mobile pump																				
		Concrete vibrator	1.73	6	3	3	54		1.73	L/h	2.08	L/h	112.10	L	159.25		1592.47		3839.56	38395.62		
6.4 Reinforcing work	2	Tower crane	75	1	2	4	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92		6058.80				4634.57	69518.52
		Truck with crane														447.00		6705.07				
		Steel cutting	2	2	2	8	32		2	Km./h	2.40	Km./h	76.80	Kw.	43.08		646.27				494.35	7415.31
6.5 Steel form demolition work	2	Tower crane	75	1	2	4	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92	403.92	6058.80	6058.80			4634.57	69518.52
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.5 The project data collection for monthly record at 5 : May 26 - June 25, 2010.

May 26 - June 25, 2010 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation	4	Back hoe	99	2	3	8	48		6	L/h	7.20	L/h	345.60	L	490.94	1344.69	3682.01	10085.15	10171.01	76282.56		
		Generator																				
		Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88		4544.10				6951.85	52138.89
		Concrete truck	280	7	1	2	14	210	3	Km./l	2.40	Km./l	87.50	L	124.30		932.22		2575.13	19313.44		
		Mobile pump	265	1	1	3	3		15.4	L/h	18.48	L/h	55.44	L	78.75		590.66		1631.60	12236.99		
		Demolition hammer	1.05	2	2	5	20		1.05	Kw./h	1.26	Kw./h	25.20	Kw.	14.14		106.03				162.21	1216.57
		Concrete vibrator	3.6	3	2	3	18		1	L/h	1.20	L/h	21.60	L	30.68		230.13		739.80	5548.50		
5.Floor work																						
5.1 Scaffolding	10	Tower crane	75	1	6	3	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	908.82	2726.46	2726.46			10427.78	31283.33
		Truck with crane																				
5.2 Wooden formwork structure	4	Tower crane	75	1	3	3	9		75	Kw./h	90.00	Kw./h	810.00	Kw.	454.41	454.41	3408.08	3404.08			5213.89	39104.17
		Truck with crane																				
5.3 Post tension slab work	5	Tower crane	75	1	5	6	30		75	Kw./h	90.00	Kw./h	2760.00	Kw.	1514.70	4307.80	9088.20	25846.82			17379.63	104277.78
		Concrete truck	280	98	5	2	980	2940	3	Km./l	2.40	Km./l	1225.00	L	1746.15		10440.90		35051.75	216310.50		
		Mobile pump	265	1	5	6	30		15.40	L/h	18.48	L/h	854.40	L	787.54		4725.25		16315.99	97895.95		
		Concrete vibrator	3.6	6	5	3	90		1.73	L/h	2.08	L/h	186.84	L	265.41		1592.47		6399.27	38395.62		
5.4 Reinforcing work	3	Tower crane	75	1	3	5	15		75	Kw./h	90.00	Kw./h	1350.00	Kw.	757.35	821.98	7573.50	8219.77			8689.82	86989.15
		Truck with crane																				
		Steel cutting	2	2	3	8	48		2	Kw./h	2.40	Kw./h	115.20	Kw.	64.63		646.27				741.53	7415.31
5.5 Steel form demolition work	3	Tower crane	75	1	1	3	3		75	Kw./h	90.00	Kw./h	270.00	Kw.	151.47	151.47	1514.70	1514.70			1737.96	17379.63
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
		Truck with crane																				
6.2 Steel form work	5	Tower crane	75	1	3	3	9		75	Kw./h	90.00	Kw./h	810.00	Kw	454.41	454.41	2726.46	2726.46			5213.89	31283.33
		Truck with crane																				
6.3 Concrete placing work	6	Tower crane	75	1	1	4	4		75	Kw./h	90.00	Kw./h	360.00	Kw.	201.96	539.21	1009.80	2696.05			2317.28	11586.42
		Concrete truck	280	17	2	2	68	510	3	Km./l	2.40	Km./l	212.50	L	301.86		1509.31		6253.88	31269.88		
		Mobile pump																				
		Concrete vibrator	3.6	4	1	3	12		1.73	L/h	2.08	L/h	24.91	L	35.39		176.94		853.24	4266.18		
6.4 Reinforcing work	2	Tower crane	75	1	6	6	36		75	Kw./h	90.00	Kw./h	3241.00	Kw.	1817.64	1860.72	27264.60	27910.87			20855.56	312833.34
		Truck with crane																				
		Steel cutting	2	2	2	8	32		2	Kw./h	2.40	Kw./h	76.80	Kw.	48.08		646.27				494.35	7415.31
6.5 Steel form demolition work	4	Tower crane	75	1	1	3	3		75	Kw./h	90.00	Kw./h	270.00	Kw.	151.47	151.47	1136.03	1136.03			1737.96	13034.72
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.6 The project data collection for monthly record at 6 : June 26 - July 25, 2010.

June 26 - July 25, 2010 (29 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	2	Tower crane	75	2	2	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	9088.20	9088.20			6951.85	104277.78
		Truck with crane																				
5.2 Wooden formwork structure	2	Tower crane	75	2	2	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	9088.20	9088.20			6951.85	104277.78
		Truck with crane																				
5.3 Post tension slab work	6	Tower crane	75	2	3	4	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	4793.60	6058.80	23967.99			13903.70	69518.52
		Concrete truck	280	128	6	2	1536	3840	3	Km./l	2.40	Km./l	1660.00	L	2275.85		11364.24		47088.00	235440.00		
		Mobile pump	265	1	7	6	42		15.40	L/h	18.48	L/h	776.16	L	1102.56		5512.79		22842.39	114211.94		
		Concrete vibrator	3.6	7	5	2	70		1.73	L/h	2.08	L/h	145.32	L	206.43		1032.16		4977.21	24886.05		
5.4 Reinforcing work	2	Tower crane	75	1	1	6	6		75	Kw./h	90.00	Kw./h	540.00	Kw.	302.94	346.02	4544.10	5190.37			3475.93	52138.89
		Truck with crane																				
		Steel cutting	2	2	2	8	32		2	Kw./h	2.40	Kw./h	76.80	Kw.	43.08		646.27				494.35	7415.31
5.5 Steel form demolition work	1	Tower crane	75	1	1	2	2		75	Kw./h	90.00	Kw./h	180.00	Kw.	100.98	100.98	3029.40	3029.40			1158.64	34759.26
6. Colum work																						
6.1 Scaffolding	2	Tower crane	75	2	1	2	4		75	Kw./h	90.00	Kw./h	360.00	Kw.	201.96	201.96	3029.40	3029.40			23117.28	34759.26
		Truck with crane																				
6.2 Steel form work	2	Tower crane	75	2	2	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	807.84	12117.60	12117.60			9269.14	139037.04
		Truck with crane																				
6.3 Concrete placing work	8	Tower crane	75	2	4	2	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	1197.99	3029.40	4492.46			9269.14	34759.26
		Concrete truck	280	14	8	2	224	420	3	Km./l	2.40	Km./l	175.00	L	248.59		932.22		5150.25	19313.44		
		Mobile pump																				
		Concrete vibrator	3.6	6	4	2	48		1.73	L/h	2.08	L/h	95.65	L	141.56		530.82		3412.94	12798.54		
6.4 Reinforcing work	2	Tower crane	75	2	2	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	850.92	12117.60	12763.87			9269.14	139037.04
		Truck with crane																				
		Steel cutting	2	2	2	8	32		2	Kw./h	2.40	Kw./h	76.80	Kw.	43.06		646.27				494.35	7415.31
6.5 Steel form demolition work	1	Tower crane	75	1	1	2	2		75	Kw./h	90.00	Kw./h	180.00	Kw.	100.98	100.98	3029.40	3029.40			1158.64	34759.26
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work	14	Tower crane	75	1	14	3	42		75	Kw./h	90.00	Kw./h	3780.00	Kw.	2120.58	2120.58	4544.10	4544.10			24331.48	52138.89
2. Rendering work	14	Tower crane	75	1	14	3	42		75	Kw./h	90.00	Kw./h	3780.00	Kw.	2120.58	2120.58	4544.10	4544.10			24331.48	52138.89
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.7 The project data collection for monthly record at 7 : July 26 – August 25, 2010.

July 26 – August 25, 2010 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	8	Tower crane	75	2	8	3	48		75	Kw./h	90.00	Kw./h	4320.00	Kw.	2423.52	2423.52	9088.20	9088.20			27807.41	104277.78
		Truck with crane																				
5.2 Wooden formwork structure	4	Tower crane	75	2	4	4	32		75	Kw./h	90.00	Kw./h	2880.00	Kw.	1615.68	1615.68	12117.80	12117.80			18538.27	139037.04
		Truck with crane																				
5.3 Post tension slab work	8	Tower crane	75	2	4	4	32		75	Kw./h	90.00	Kw./h	2880.00	Kw.	1615.68	4943.22	6058.80	18537.08			18538.27	69518.52
		Concrete truck	280	128	8	2	2048	3840	3	Km./l	2.40	Km./l	1600.00	L	2272.85		8523.18		47088.00	176580.00		
		Mobile pump	265	1	8	3	24		15.40	L/h	18.48	L/h	443.52	L	630.03		2362.63		13052.79	48947.98		
		Concrete vibrator	3.6	6	8	3	144		1.73	L/h	2.08	L/h	298.94	L	424.06		1592.47		10238.83	38395.62		
5.4 Reinforcing work	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.75	1297.93	9088.20	9734.47			13903.70	104277.78
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
5.5 Steel form demolition work	4	Tower crane	75	1	1	3	3		75	Kw./h	90.00	Kw./h	270.00	Kw.	151.47	151.47	1136.03	1136.03			1737.96	13034.72
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
6.2 Steel form work	5	Tower crane	75	2	5	4	40		75	Kw./h	90.00	Kw./h	3600.00	Kw.	2019.60	2019.60	12117.50	12117.50			23172.84	139037.04
		Truck with crane																				
6.3 Concrete placing work	12	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.75	2132.85	3029.40	5332.14			13903.70	34759.26
		Concrete truck	280	16	4	2	128	480	3	Km./l	2.40	Km./l	200.00	L	284.11		710.27		5886.00	14715.00		
		Mobile pump																				
		Concrete vibrator	3.6	6	12	3	216		1.73	L/h	2.08	L/h	448.42	L	636.99		1592.47		15358.25	38395.02		
6.4 Reinforcing work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	648.96	4544.10	4867.24			6951.85	52138.89
		Truck with crane																				
		Steel cutting	2	2	2	8	32		2	Kw./h	2.40	Kw./h	76.80	Kw.	43.08		323.14				494.35	3707.65
6.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
7. Precast installation	28	Tower crane	75	2	28	6	336		75	Kw./h	90.00	Kw./h	30240.00	Kw.	16964.64	19361.78	18176.40	20744.77			194651.86	208555.56
		Trailer	184	54	27	2	2915	5400	4	Km./L	3.20	Km./L	1687.50	L	2397.14		2568.37		49663.13	53210.49		
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work	8	Tower crane	75	1	8	3	192		75	Kw./h	90.00	Kw./h	17280.00	Kw.	9694.08	9694.08	36352.80	36352.80			111229.63	417111.12
2. Rendering work	10	Tower crane	75	1	10	3	300		75	Kw./h	90.00	Kw./h	27000.00	Kw.	15147.00	15147.00	45441.00	45441.00			173796.30	521388.90
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.8 The project data collection for monthly record at 8 : August 26 - September 25, 2010.

August 26 - September 25, 2010 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	8	Tower crane	75	2	8	3	48		75	Kw./h	90.00	Kw./h	4320.00	Kw.	2423.52	2423.52	9088.20	9088.20			27807.41	104277.78
		Truck with crane																				
5.2 Wooden formwork structure	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
5.3 Post tension slab work	7	Tower crane	75	2	7	6	84		75	Kw./h	90.00	Kw./h	7560.00	Kw.	4241.16	6720.41	18176.40	28801.74			48662.96	208555.56
		Concrete truck	280	98	7	2	1372	2940	3	Km./l	2.40	Km./l	1225.00	L	1740.15		7457.78		36051.75	154507.50		
		Mobile pump	265	1	7	2	14		15.40	L/h	18.48	L/h	258.72	L	367.52		1575.08		7614.13	32631.98		
		Concrete vibrator	3.6	6	7	3	126		1.73	L/h	2.08	L/h	261.58	L	371.58		1592.47		8958.98	38395.62		
5.4 Reinforcing work	4	Tower crane	75	2	4	2	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	840.15	6058.80	6301.15			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	3	24		2	Kw./h	2.40	Kw./h	57.60	Kw.	32.31		242.35				370.77	2780.74
5.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	2	4	2	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	807.84	6058.80	6058.80			9269.14	69518.52
		Truck with crane																				
6.2 Steel form work	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
6.3 Concrete placing work	9	Tower crane	75	2	4	4	32		75	Kw./h	90.00	Kw./h	2880.00	Kw.	1615.68	2270.99	5385.60	7669.96			18538.27	61794.24
		Concrete truck	280	10	3	2	60	300	3	Km./l	2.40	Km./l	125.00	L	177.57		591.89		3678.75	12262.50		
		Mobile pump																				
		Concrete vibrator	3.6	6	9	3	162		1.73	L/h	2.08	L/h	336.31	L	477.74		1592.47		11518.69	38395.62		
6.4 Reinforcing work	4	Tower crane	75	1	4	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	894.01	6058.80	6705.07			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
6.5 Steel form demolition work	4	Tower crane	75	1	4	2	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92	403.92	3029.40	3029.40			4634.57	34759.26
7. Precast installation	21	Tower crane	75	2	21	6	252		75	Kw./h	90.00	Kw./h	22680.00	Kw.	12723.48	14543.53	18176.40	20776.48			145988.89	208555.56
		Trailer	184	41	21	2	1722	4100	4	Km./L	3.20	Km./L	1281.25	L	1820.05		2600.08		37707.19	53867.41		
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	4	Site elevator														26.63		199.76				
		Truck with crane	92	1	2	8	16		4	Km./L	3.20	Km./L	18.75	L	26.63		199.76		551.81	4138.59		
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.9 The project data collection for monthly record at 9 : September 26 - October 25, 2010.

Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
September 26 - October 25, 2010 (29 Days)																						
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	6	Tower crane	75	2	6	2	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	8058.80	8058.80			13903.70	69518.52
		Truck with crane																				
5.2 Wooden formwork structure	4	Tower crane	75	2	4	4	32		75	Kw./h	90.00	Kw./h	2880.00	Kw.	1615.68	1615.68	12117.60	12117.60			18538.27	139037.04
		Truck with crane																				
5.3 Post tension slab work	8	Tower crane	75	2	8	4	64		75	Kw./h	90.00	Kw./h	5760.00	Kw.	3231.36	6558.90	12117.60	24595.88			37076.54	139037.04
		Concrete truck	280	128	8	2	2048	3840	3	Km./l	2.40	Km./l	1600.00	L	2272.85		8523.18		47088.00	176580.00		
		Mobile pump	265	1	8	3	24		15.40	L/h	18.48	L/h	443.52	L	630.03		2362.63		13052.79	48947.98		
		Concrete vibrator	3.6	6	8	3	144		1.73	L/h	2.08	L/h	298.94	L	424.66		1592.47		10238.83	38395.62		
5.4 Reinforcing work	7	Tower crane	75	2	7	3	42		75	Kw./h	90.00	Kw./h	3780.00	Kw.	2120.58	2271.38	9088.20	9734.47			24331.48	104277.78
		Truck with crane																				
		Steel cutting	2	2	7	8	112		2	Kw./h	2.40	Kw./h	268.80	Kw.	150.80		646.27				1730.24	7415.31
5.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
6.2 Steel form work	7	Tower crane	75	2	7	3	42		75	Kw./h	90.00	Kw./h	3780.00	Kw.	2120.58	2120.58	9088.20	9088.20			24331.48	104277.78
		Truck with crane																				
6.3 Concrete placing work	12	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1584.15	3029.40	3960.37			18538.27	61794.24
		Concrete truck	280	13	4	3	156	390	3	Km./l	2.40	Km./l	162.50	L	230.84		577.09		4782.38	11955.94		
		Mobile pump																				
		Concrete vibrator	3.6	6	4	2	48		1.73	L/h	2.08	L/h	99.65	L	141.55		353.88		3412.94	8532.36		
6.4 Reinforcing work	4	Tower crane	75	1	4	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	894.01	6058.80	6705.07			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
6.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
7. Precast installation	28	Tower crane	75	2	28	6	336		75	Kw./h	90.00	Kw./h	30240.00	Kw.	16964.64	19361.78	18176.40	20744.77			194651.86	208555.56
		Trailer	184	54	27	2	2916	5400	4	Km./l	3.20	Km./l	1687.50	L	2397.14		2568.37		49663.13	53210.49		
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	29	Site elevator	66	2	29	10	580		66	Kw./h	79.20	Kw./h	45936.00	Kw.	25770.10	25770.10	26658.72	26658.72			295685.44	305881.49
Architectural Activities																						
1. Masonry work	16	Tower crane	75	2	16	3	96		75	Kw./h	90.00	Kw./h	8640.00	Kw.	4847.04	4847.04	9088.20	9088.20			55614.82	104277.78
2. Rendering work	20	Tower crane	75	2	20	3	120		75	Kw./h	90.00	Kw./h	10800.00	Kw.	6058.80	6058.80	9088.20	9088.20			69518.52	104277.78
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work	7	Site elevator	66	1	3	2	6		66	Kw./h	79.20	Kw./h	475.20	Kw.	266.59	266.59	1142.52	1142.52			3058.81	13109.21
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	7	Site elevator	66	2	4	8	64		66	Kw./h	79.20	Kw./h	5068.80	Kw.	2843.60	2870.23	12186.84	12300.99			32627.36	46610.51
		Truck with crane	92	1	2	3	3	30	4	Km./l	3.20	Km./l	18.75	L	26.63		114.15		551.81	2364.91		
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.10 The project data collection for monthly record at 10 : October 26 - November 25, 2010.

October 26 - November 25, 2010 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	25	Back hoe	99	1	25	8	200		6	L/h	7.20	L/h	1440.00	L	2045.56	2045.56	2454.88	2454.88	42379.20	50855.04		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	6	Tower crane	75	2	6	3	36		75	Kw./h	90.00	Kw./h	3240.00	Kw.	1817.64	1817.64	9088.20	9088.20			20855.56	104277.78
		Truck with crane																				
5.2 Wooden formwork structure	9	Tower crane	75	2	9	4	72		75	Kw./h	90.00	Kw./h	6480.00	Kw.	3635.28	3635.28	12117.60	12117.60			41711.11	139037.94
		Truck with crane																				
5.3 Post tension slab work	8	Tower crane	75	2	8	4	64		75	Kw./h	90.00	Kw./h	5760.00	Kw.	3231.36	6348.89	12117.60	23808.33			37076.54	139037.04
		Concrete truck	280	128	8	2	2048	3840	3	Km./l	2.40	Km./l	1600.00	L	2272.85		8523.18		47088.00	176580.00		
		Mobile pump	265	1	8	2	16		15.40	L/h	18.48	L/h	295.68	L	420.02		1575.08		8701.86	32631.98		
		Concrete vibrator	3.6	6	8	3	144		1.73	L/h	2.08	L/h	298.94	L	424.66		1592.47		10238.83	38395.62		
5.4 Reinforcing work	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1297.93	9088.20	9734.47			13903.70	104277.78
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
5.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
6. Colum work																						
6.1 Scaffolding	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
6.2 Steel form work	6	Tower crane	75	2	6	3	36		75	Kw./h	90.00	Kw./h	3240.00	Kw.	1817.64	1817.64	9088.20	9088.20			20855.56	104277.78
		Truck with crane																				
6.3 Concrete placing work	12	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1584.15	3029.40	3960.37			13903.70	34759.26
		Concrete truck	280	13	4	2	104	390	3	Km./l	2.40	Km./l	162.50	L	230.84		577.09		4782.38	11955.94		
		Mobile pump																				
		Concrete vibrator	3.6	6	4	2	48		1.73	L/h	2.08	L/h	99.65	L	141.55		353.88		3412.94	8532.36		
6.4 Reinforcing work	4	Tower crane	75	1	4	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	894.01	6058.80	6705.07			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
6.5 Steel form demolition work	4	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
7. Precast installation	28	Tower crane	75	2	28	8	448		75	Kw./h	90.00	Kw./h	40320.00	Kw.	22619.52	25016.66	24235.20	26803.57			259535.81	278074.08
		Trailer	184	54	27	2	2916	5400	4	Km./l	3.20	Km./l	1687.50	L	2397.14		2568.37		49663.13	53210.49		
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	30	Site elevator	66	2	30	10	600		66	Kw./h	79.20	Kw./h	47520.00	Kw.	26658.72	26658.72	26658.72	26658.72			305881.49	305881.49
Architectural Activities																						
1. Masonry work	24	Tower crane	75	2	24	3	144		75	Kw./h	90.00	Kw./h	12960.00	Kw.	7270.56	7270.56	9088.20	9088.20			83422.22	104277.78
2. Rendering work	24	Tower crane	75	2	24	3	144		75	Kw./h	90.00	Kw./h	12960.00	Kw.	7270.56	7270.56	9088.20	9088.20			83422.22	104277.78
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work	2	Site elevator	66	1	2	3	6		66	Kw./h	79.20	Kw./h	476.20	Kw.	266.59	266.59	3998.81	3998.81			3058.81	45882.22
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	4	Site elevator	66	2	2	6	20		66	Kw./h	79.20	Kw./h	1584.00	Kw.	888.62	888.62	6664.68	6664.68			10196.05	14565.79
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system	21	Tower crane	75	1	12	2	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	6678.90	1731.09	9541.28			13903.70	19862.43
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.00	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	1	21	8	168		2	Kw./h	2.40	Kw./h	403.20	Kw.	226.20		323.14				2595.36	3707.65
		Impact drilling	0.78	4	21	6	504		0.78	Kw./h	0.94	Kw./h	471.74	Kw.	264.65		378.07				3036.57	4337.96

Table A.11 The project data collection for monthly record at 11 : November 26 – December 25, 2010.

November 26 – December 25, 2010 (29 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	F Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	5	Back hoe	99	1	5	8	40		6	L/h	7.20	L/h	288.00	L	409.11	409.11	2454.68	2454.68	8475.84	8475.84		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding	4	Tower crane	75	2	3	4	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13,903.70	104,277.78
		Truck with crane																				
5.2 Wooden formwork structure	3	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
5.3 Post tension slab work	6	Tower crane	75	2	7	6	84		75	Kw./h	90.00	Kw./h	7560.00	Kw.	4241.16	6720.41	18176.40	28801.74			48662.96	208555.56
		Concrete truck	280	98	7	2	1372	2940	3	Km./l	2.40	Km./l	1225.00	L	1740.15		7457.78		36051.75	154507.50		
		Mobile pump	265	1	7	2	14		15.40	L/h	18.48	L/h	258.72	L	367.52		1575.08		7614.13	32631.98		
		Concrete vibrator	3.6	6	7	3	126		1.73	L/h	2.08	L/h	261.58	L	371.58		1592.47		8958.98	38395.62		
5.4 Reinforcing work	12	Tower crane	75	2	4	2	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	840.15	6058.80	6301.15			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	3	24		2	Kw./h	2.40	Kw./h	57.60	Kw.	32.31		242.35				370.77	2780.74
5.5 Steel form demolition work	3	Tower crane	75	1	4	3	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	605.88	4544.10	4544.10			6951.85	52138.89
6. Colum work																						
6.1 Scaffolding	6	Tower crane	75	2	4	2	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	807.84	6058.80	6058.80			9269.14	69518.52
		Truck with crane																				
6.2 Steel form work	4	Tower crane	75	2	4	3	24		75	Kw./h	90.00	Kw./h	2160.00	Kw.	1211.76	1211.76	9088.20	9088.20			13903.70	104277.78
		Truck with crane																				
6.3 Concrete placing work	9	Tower crane	75	2	4	4	32		75	Kw./h	90.00	Kw./h	2880.00	Kw.	1615.68	2270.99	5385.60	7669.96			18538.27	61794.24
		Concrete truck	280	10	3	2	60	300	3	Km./l	2.40	Km./l	125.00	L	177.57		591.89		3678.75	12262.50		
		Mobile pump																				
		Concrete vibrator	3.6	6	9	3	162		1.73	L/h	2.08	L/h	336.31	L	477.74		1592.47		11518.69	38395.62		
6.4 Reinforcing work	9	Tower crane	75	1	4	4	16		75	Kw./h	90.00	Kw./h	1440.00	Kw.	807.84	894.01	6058.80	6705.07			9269.14	69518.52
		Truck with crane																				
		Steel cutting	2	2	4	8	64		2	Kw./h	2.40	Kw./h	153.60	Kw.	86.17		646.27				988.71	7415.31
6.5 Steel form demolition work	6	Tower crane	75	1	4	2	8		75	Kw./h	90.00	Kw./h	720.00	Kw.	403.92	403.92	3029.40	3029.40			4634.57	34759.26
7. Precast installation	14	Tower crane	75	2	21	6	252		75	Kw./h	90.00	Kw./h	22680.00	Kw.	12723.48	14543.53	18176.40	20776.48			145988.89	208555.56
		Trailer	184	41	21	2	1722	4100	4	Km./l	3.20	Km./l	1281.25	L	1820.05		2600.08		37707.19	53867.41		
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	25	Back hoe	99	1	25	8	200		6	L/h	7.20	L/h	1440.00	L	2045.56	4317.61	2454.68	5181.14	42379.20	50855.04		
		Tower crane	75	1	15	3	45		75	Kw./h	90.00	Kw./h	4050.00	Kw.	2272.05		2726.46				26069.45	31283.33
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	29	Site elevator	66	2	29	10	580		66	Kw./h	79.20	Kw./h	45936.00	Kw.	25770.10	25770.10	26658.72	26658.72			295685.44	305881.49
Architectural Activities																						
1. Masonry work	28	Tower crane	75	2	28	3	168		75	Kw./h	90.00	Kw./h	15120.00	Kw.	8482.32	8482.32	9088.20	9088.20			97325.93	104277.78
2. Rendering work	29	Tower crane	75	2	29	3	174		75	Kw./h	90.00	Kw./h	15660.00	Kw.	8786.26	8786.26	9088.20	9088.20			100801.85	104277.78
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work	3	Site elevator	75	1	3	3	9		66	Kw./h	79.20	Kw./h	712.80	Kw.	399.88	399.88	3998.81	3998.81			4588.22	45882.22
8. Tile, floor and terrazzo work	13	Site elevator	175	2	9	3	65		66	Kw./h	79.20	Kw./h	4276.80	Kw.	2399.28	2399.28	5536.81	5536.81			27529.33	63529.23
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	11	Site elevator	66	1	2	5	10		66	Kw./h	79.20	Kw./h	792.00	Kw.	444.31	444.31	1211.76	1211.76			5098.02	7282.89
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system	7	Tower crane	75	1	3	2	6		75	Kw./h	90.00	Kw./h	540.00	Kw.	302.94	1908.55	1298.31	8179.50			3475.93	14896.83
		Electrical welding	11	4	7	7	196		11	Kw./h	13.20	Kw./h	2587.20	Kw.	1451.42		6220.37				16653.55	71372.35
		Steel cutting	2	1	7	7	49		2	Kw./h	2.40	Kw./h	117.60	Kw.	65.97		282.74				756.98	3244.20
		Impact drilling	0.78	4	7	6	168		0.78	Kw./h	0.94	Kw./h	157.25	Kw.	88.22		378.07				1012.19	4337.96

Table A.12 The project data collection for monthly record at 12 : December 26 - January 25, 2011.

December 26 - January 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation	21	Tower crane	75	2	21	8	336		75	Kw./h	90.00	Kw./h	30240.00	Kw.	16964.64	18740.30	24235.20	26771.86			194651.86	278074.08
		Trailer	184	40	20	2	1600	4000	4	Km./l	3.20	Km./l	1250.00	L	1775.66		2536.66		36787.50	52553.57		
8. Water tanks on the property	10	Tower crane	75	2	10	4	80		75	Kw./h	90.00	Kw./h	7200.00	Kw.	4039.20	4039.20	12117.60	12117.60			46345.68	139037.04
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	22	Back hoe	99	1	22	8	178		6	L/h	7.20	L/h	1267.20	L	1800.10	3819.70	2454.68	5208.68	37293.70	111881.09		
		Tower crane	75	1	10	4	40		75	Kw./h	90.00	Kw./h	3600.00	Kw.	2019.60		2754.00				23172.84	31599.33
10. Roads and surrounding ground	4	Back hoe	99	1	4	8	32		6	L/h	7.20	L/h	230.40	L	327.29	327.29	2454.68	2454.68	6780.67	50855.04		
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	30	Site elevator	66	2	30	8	480		66	Kw./h	79.20	Kw./h	38016.00	Kw.	21326.98	21326.98	21326.98	21326.98			244705.19	244705.19
Architectural Activities																						
1. Masonry work	30	Tower crane	75	2	30	3	180		75	Kw./h	90.00	Kw./h	16200.00	Kw.	9088.20	9088.20	9088.20	9088.20			104277.78	104277.78
2. Rendering work	30	Tower crane	75	2	30	3	180		75	Kw./h	90.00	Kw./h	16200.00	Kw.	9088.20	9088.20	9088.20	9088.20			104277.78	104277.78
3. Ceiling work	20	Site elevator	66	2	20	5	200		66	Kw./h	79.20	Kw./h	15840.00	Kw.	8886.24	9138.29	13329.36	13707.43			101960.50	152940.74
		Impact drilling	0.78	4	20	6	480		0.78	Kw./h	0.94	Kw./h	449.28	Kw.	252.05		378.07				2891.97	4337.96
4. Doors and windows work	30	Site elevator	66	2	30	6	360		66	Kw./h	79.20	Kw./h	28512.00	Kw.	15995.23	1645.69	15995.23	16454.69			183528.89	183528.89
		Electric drilling	0.65	5	30	7	1050		0.65	Kw./h	0.78	Kw./h	819.00	Kw.	459.46		459.46				5271.82	5271.82
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work		Site elevator																				
7. Topping covering work	12	Site elevator	66	2	4	3	24		66	Kw./h	79.20	Kw./h	1900.80	Kw.	1066.35	1066.35	2665.87	2665.87			12235.26	30588.15
8. Tile, floor and terrazzo work	10	Site elevator	66	1	5	3	15		66	Kw./h	79.20	Kw./h	1188.00	Kw.	666.47	666.47	1999.40	1999.40			7647.04	22941.11
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1037.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	20		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	78	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	10	Site elevator	66	1	5	4	20		66	Kw./h	79.20	Kw./h	1584.00	Kw.	888.62	888.62	2665.87	2665.87			10196.05	14565.79
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system	12	Tower crane	75	1	5	2	10		75	Kw./h	90.00	Kw./h	900.00	Kw.	504.90	3628.98	1262.25	9072.45			5793.21	14483.03
		Electrical welding	11	4	12	8	384		11	Kw./h	13.20	Kw./h	5068.80	Kw.	2843.60		7108.99				32627.36	81568.40
		Steel cutting	2	1	12	8	96		2	Kw./h	2.40	Kw./h	230.40	Kw.	129.25		323.14				1483.06	3707.65
		Impact drilling	0.78	4	12	6	288		0.78	Kw./h	0.94	Kw./h	269.57	Kw.	151.23		378.07				1735.18	4337.96

Table A.13 The project data collection for monthly record at 13 : January 26 – February 25, 2011.

January 26 – February 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO_2 kg	Total CO_2 kg	CO_2 (kg./Month)	Total CO_2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane												.								
7. Precast installation	21	Tower crane	75	2	21	6	252		75	Kw./h	90.00	Kw./h	22680.00	Kw.	12723.48	14321.56	18176.40	20459.39			145988.89	208555.56
		Trailer	184	36	18	2	1296	3600	4	Km./l	3.20	Km./l	1125.00	L	1598.10		2282.99		33108.75	47298.21		
8. Water tanks on the property	9	Tower crane	75	1	9	4	36		75	Kw./h	90.00	Kw./h	3240.00	Kw.	1817.64	1817.64	6058.80	6058.80			20855.56	69518.52
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	16	Back hoe	99	1	16	8	128		6	L/h	7.20	L/h	921.60	L	1309.16	1309.16	2454.68	2454.68	27122.69	90408.96		
		Tower crane																			26069.45	31283.33
10. Roads and surrounding ground	5	Back hoe	99	1	5	8	40		6	L/h	7.20	L/h	288.00	L	409.11	886.41	2454.68	5318.47	8475.84	50855.04		
		Rolling compactor	93	1	5	8	40		7	L/h	8.40	L/h	336.00	L	477.30		2863.79		9888.48	59330.88		
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work	26	Tower crane	75	2	18	3	108		75	Kw./h	90.00	Kw./h	9720.00	Kw.	5452.92	5452.92	6291.83	6291.83			62566.67	72192.31
2. Rendering work	26	Tower crane	75	2	18	3	108		75	Kw./h	90.00	Kw./h	9720.00	Kw.	5452.92	5452.92	6291.83	6291.83			62566.67	72192.31
3. Ceiling work	16	Site elevator	66	2	16	5	160		66	Kw./h	79.20	Kw./h	12672.00	Kw.	7108.99	7310.63	13329.36	13707.43			81568.40	152940.74
		Impact drilling	0.78	4	16	6	384		0.78	Kw./h	0.94	Kw./h	359.42	Kw.	201.64		378.07				2313.58	4337.96
4. Doors and windows work	10	Site elevator	66	2	10	3	60		66	Kw./h	79.20	Kw./h	4752.00	Kw.	2665.87	2819.03	7997.62	8457.08			30588.15	91764.45
		Electric drilling	0.65	5	10	7	350		0.65	Kw./h	0.78	Kw./h	273.00	Kw.	153.15		459.46				1757.27	5271.82
5. Sanitary and hygiene fitting	3	Site elevator	66	1	3	4	12		66	Kw./h	79.20	Kw./h	950.40	Kw.	533.17	533.17	5331.74	5331.74			6117.63	61176.30
6. Painting work		Site elevator																				
7. Topping covering work	18	Site elevator	66	2	18	3	108		66	Kw./h	79.20	Kw./h	8556.60	Kw.	4798.57	4798.57	7997.62	7997.62			55058.67	91764.45
8. Tile, floor and terrazzo work	20	Site elevator	66	1	10	3	30		66	Kw./h	79.20	Kw./h	2376.00	Kw.	1332.94	1332.94	1999.40	1999.40			15294.07	22941.11
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	3	Site elevator	66	1	4	3	12		66	Kw./h	79.20	Kw./h	950.40	Kw.	533.17	533.17	5331.74	5331.74			6117.63	61176.30
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	18	Site elevator	66	1	9	6	54		66	Kw./h	79.20	Kw./h	4276.80	Kw.	2399.28	2399.28	3998.81	3998.81			27529.33	39327.62
		Truck with crane																				
9. Electrical Supply	20	Site elevator	66	1	20	1	20		66	Kw./h	79.20	Kw./h	1584.00	Kw.	888.62	888.62	1332.94	1332.94			10196.05	15294.07
10. Fire alarm system	15	Tower crane	75	1	6	2	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88	4510.98	1211.76	9021.96			6951.85	13903.70
		Electrical welding	11	4	15	8	480		11	Kw./h	13.20	Kw./h	6336.00	Kw.	3554.50		7108.99				40784.20	81568.40
		Steel cutting	2	1	15	8	120		2	Kw./h	2.40	Kw./h	288.00	Kw.	161.57		323.14				1853.83	3707.65
		Impact drilling	0.78	4	15	6	360		0.78	Kw./h	0.94	Kw./h	336.96	Kw.	189.03		378.07				2168.98	4337.96

Table A.14 The project data collection for monthly record at 14 : February 26 – March 25, 2011.

February 26 – March 25, 2011 (27 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane												.								
7. Precast installation	27	Tower crane	75	2	27	6	324		75	Kw./h	90.00	Kw./h	29160.00	Kw.	16358.76	17690.51	18176.40	19656.12			187700.00	208555.56
		Trailer	184	30	15	2	900	3000	4	Km./l	3.20	Km./l	937.50	L	1331.75		1479.72		27590.63	30656.25		
8. Water tanks on the property	5	Tower crane	75	1	5	4	20		75	Kw./h	90.00	Kw./h	1800.00	Kw.	1009.80	1009.80	6058.80	6058.80			11586.42	69518.52
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	5	Back hoe	99	1	5	8	40		6	L/h	7.20	L/h	288.00	L	409.11	1014.99	2454.68	6089.96	8475.84	50855.04		
		Tower crane	75	1	3	4	12		75	Kw./h	90.00	Kw./h	1080.00	Kw.	605.88		3635.28				6951.85	41711.11
10. Roads and surrounding ground	10	Back hoe	99	1	10	8	80		6	L/h	7.20	L/h	576.00	L	818.23	1208.50	2454.68	3625.49	16951.68	50855.04		
		Rolling compactor																				
		Concrete truck	280	16	2	2	64	480	3	Km/l	2.40	Km./l	200.00	L	284.11		852.32		5886.00	17658.00		
		Concrete vibrator	3.60	6	2	3	36		1.73	L/h	2.08	L/h	74.74	L	106.16		318.49		2559.71	7679.12		
11. Labors and material transport	27	Site elevator	66	1	27	8	216		66	Kw./h	79.20	Kw./h	17107.20	Kw.	9597.14	9597.14	10663.49	10663.49			110117.34	122352.60
Architectural Activities																						
1. Masonry work	26	Tower crane	75	2	26	3	156		75	Kw./h	90.00	Kw./h	14040.00	Kw.	7876.44	7876.44	9088.20	9088.20			90374.08	104277.78
2. Rendering work	23	Tower crane	75	2	22	3	132		75	Kw./h	90.00	Kw./h	11880.00	Kw.	6664.68	6664.68	8693.06	8693.06			76470.37	99743.96
3. Ceiling work	27	Site elevator	66	1	27	4	108		66	Kw./h	79.20	Kw./h	8553.60	Kw.	4798.57	5252.25	5331.74	5835.84			55058.67	61176.30
		Impact drilling	0.78	4	27	8	864		0.78	Kw./h	0.94	Kw./h	808.70	Kw.	453.68		504.09				5205.55	5783.94
4. Doors and windows work	20	Site elevator	66	1	20	2	40		66	Kw./h	79.20	Kw./h	3168.00	Kw.	1777.25	2083.55	2665.87	3125.33			20392.10	30588.15
		Electric drilling	0.65	5	20	7	700		0.65	Kw./h	0.78	Kw./h	546.00	Kw.	306.31		459.46				3514.55	5271.82
5. Sanitary and hygiene fitting	9	Site elevator	66	2	9	4	72		66	Kw./h	79.20	Kw./h	5702.40	Kw.	3199.05	3199.05	10663.49	10663.49			36705.78	122352.60
6. Painting work	27	Site elevator	66	1	15	3	45		66	Kw./h	79.20	Kw./h	3564.00	Kw.	1999.40	1999.40	2221.56	2221.56			22941.11	25490.12
7. Topping covering work	16	Site elevator	66	2	8	3	48		66	Kw./h	79.20	Kw./h	3801.60	Kw.	2132.70	2132.70	3998.81	3998.81			24470.52	45882.22
8. Tile, floor and terrazzo work	24	Site elevator	66	2	18	3	108		66	Kw./h	79.20	Kw./h	8553.60	Kw.	4798.57	4798.57	5536.21	5536.21			55058.67	63523.23
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6541.08	1298.31	9344.40			10427.78	14896.83
		PPR Welding	0.80	1	21	8	168		0.80	Kw./h	0.96	Kw./h	161.28	Kw.	90.48		129.25				1038.14	1483.06
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
4. Waste Water System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
5. Vent System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
6. Soil System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.10	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
7. Storm Drainage System	21	Tower crane	75	1	9	2	18		75	Kw./h	90.00	Kw./h	1620.00	Kw.	908.82	6575.01	1298.31	9392.87			10427.78	14896.83
		PPR Welding	1.1	1	21	8	168		1.10	Kw./h	1.32	Kw./h	221.76	Kw.	124.41		177.72				1427.45	2039.21
		Electrical Welding	11	4	21	8	672		11	Kw./h	13.20	Kw./h	8870.40	Kw.	4976.29		7108.99				57097.88	81568.40
		Steel cutting	2	4	21	5	420		2	Kw./h	2.40	Kw./h	1008.00	Kw.	565.49		807.84				6488.40	9269.14
8. Wiring System	25	Site elevator	66	1	12	8	96		66	Kw./h	79.20	Kw./h	7603.20	Kw.	4265.40	4265.40	5118.47	5118.47			48941.04	69915.77
		Truck with crane																				
9. Electrical Supply	27	Site elevator	75	1	27	2	54		66	Kw./h	79.20	Kw./h	4276.80	Kw.	2399.28	2399.28	2665.87	2665.87			27529.33	30588.15
10. Fire alarm system	12	Tower crane	75	1	5	2	10		75	Kw./h	90.00	Kw./h	900.00	Kw.	504.90	3628.98	1262.25	9072.45			5793.21	14483.03
		Electrical welding	11	4	12	8	384		11	Kw./h	13.20	Kw./h	5068.80	Kw.	2843.60		7108.99				32627.36	81568.40
		Steel cutting	2	1	12	8	96		2	Kw./h	2.40	Kw./h	230.40	Kw.	129.25		323.14				1483.06	3707.65
		Impact drilling	0.78	4	12	6	288		0.78	Kw./h	0.94	Kw./h	269.57	Kw.	151.23		378.07				1735.18	4337.96

Table A.15 The project data collection for monthly record at 15 : March 26 – April 25, 2011.

March 26 – April 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	5	Back hoe	99	1	5	8	40		6	L/h	7.20	L/h	288.00	L	409.11	409.11	2454.68	2454.68	8475.84	50855.04		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	5	Back hoe	99	1	5	8	40		6	L/h	7.20	L/h	288.00	L	409.11	1166.46	2454.68	6998.78	8475.84	50855.04		
		Tower crane	75	1	5	3	15		75	Kw/h	90.00	Kw/h	1350.00	Kw.	757.35		4544.10				8689.82	52138.89
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	30	Site elevator	66	2	30	10	600		66	Kw/h	79.20	Kw/h	47520.00	Kw.	26658.72	26658.72	26658.72	26658.72			305881.49	305881.49
Architectural Activities																						
1. Masonry work	30	Tower crane	75	2	30	3	180		75	Kw/h	90.00	Kw/h	16200.00	Kw.	9088.20	9088.20	9088.20	9088.20			104277.78	104277.78
2. Rendering work	30	Tower crane	75	2	30	3	180		75	Kw/h	90.00	Kw/h	16200.00	Kw.	9088.20	9088.20	9088.20	9088.20			104277.78	104277.78
3. Ceiling work	15	Site elevator	66	2	15	5	150		66	Kw/h	79.20	Kw/h	11880.00	Kw.	6664.68	6853.71	13329.36	13707.43			76470.37	152940.74
		Impact drilling	0.78	4	15	6	360		0.78	Kw/h	0.94	Kw/h	336.96	Kw.	189.03		348.07				2168.98	4337.96
4. Doors and windows work	15	Site elevator	66	2	15	6	180		66	Kw/h	79.20	Kw/h	14256.00	Kw.	7997.62	8227.35	15995.23	16454.69			91764.45	183528.89
		Electric drilling	0.65	5	15	7	525		0.65	Kw/h	0.78	Kw/h	409.50	Kw.	229.73		459.46				2635.91	5271.82
5. Sanitary and hygiene fitting	21	Site elevator	66	2	21	4	168		66	Kw/h	79.20	Kw/h	13305.60	Kw.	7464.44	7464.44	10663.49	10663.49			85646.82	122352.60
6. Painting work	10	Site elevator	66	1	6	3	18		66	Kw/h	79.20	Kw/h	1425.50	Kw.	799.76	799.76	2399.28	2399.28			9176.44	27529.33
7. Topping covering work	6	Site elevator	66	1	6	3	18		66	Kw/h	79.20	Kw/h	1425.50	Kw.	799.76	799.76	3998.81	3998.81			9176.44	45882.22
8. Tile, floor and terrazzo work	13	Site elevator	66	2	10	3	60		66	Kw/h	9.20	Kw/h	4752.00	Kw.	2665.87	2665.87	6152.01	6152.01			30588.15	70588.04
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	20	Site elevator	66	1	20	5	100		66	Kw/h	79.20	Kw/h	7920.00	Kw.	4443.12	4443.12	6664.68	6664.68			50980.25	76470.37
3. Cold Water System	28	Tower crane	75	2	12	2	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2423.52	9933.20	2596.63	10642.71			27807.41	29793.65
		PPR Welding	0.80	1	28	8	224		0.80	Kw/h	0.96	Kw/h	215.04	Kw.	120.64		129.25				1384.19	1483.06
		Electrical Welding	11	4	28	8	896		11	Kw/h	13.20	Kw/h	11827.20	Kw.	6635.06		7108.99				76130.50	81568.40
		Steel cutting	2	4	28	5	560		2	Kw/h	2.40	Kw/h	1344.00	Kw.	753.98		807.84				8651.19	9269.14
4. Waste Water System	28	Tower crane	75	2	12	2	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2426.52	9978.44	2596.63	10691.19			27807.41	29793.65
		PPR Welding	1.10	1	28	8	224		1.10	Kw/h	1.32	Kw/h	295.68	Kw.	165.88		177.72				1903.26	2039.21
		Electrical Welding	11	4	28	8	896		11	Kw/h	13.20	Kw/h	11827.20	Kw.	6635.06		7108.99				76130.50	81568.40
		Steel cutting	2	4	28	5	560		2	Kw/h	2.40	Kw/h	1344.00	Kw.	753.98		807.84				8651.19	9269.14
5. Vent System	28	Tower crane	75	2	12	2	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2426.52	9978.44	2596.63	10691.19			27807.41	29793.65
		PPR Welding	1.10	1	28	8	224		1.10	Kw/h	1.32	Kw/h	295.68	Kw.	165.88		177.72				1903.26	2039.21
		Electrical Welding	11	4	28	8	896		11	Kw/h	13.20	Kw/h	11827.20	Kw.	6635.06		7108.99				76130.50	81568.40
		Steel cutting	2	4	28	5	560		2	Kw/h	2.40	Kw/h	1344.00	Kw.	753.98		807.84				8651.19	9269.14
6. Soil System	28	Tower crane	75	2	12	2	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2426.52	9978.44	2596.63	10691.19			27807.41	29793.65
		PPR Welding	1.10	1	28	8	224		1.10	Kw/h	1.32	Kw/h	295.68	Kw.	165.88		177.72				1903.26	2039.21
		Electrical welding	11	4	28	8	896		11	Kw/h	13.20	Kw/h	11827.20	Kw.	6635.06		7108.99				76130.50	81568.40
		Steel cutting	2	4	28	5	560		2	Kw/h	2.40	Kw/h	1344.00	Kw.	753.98		807.84				8651.19	9269.14
7. Storm Drainage System	28	Tower crane	75	2	12	2	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2426.52	9978.44	2596.63	10691.19			27807.41	29793.65
		PPR Welding	1.10	1	28	8	224		1.10	Kw/h	1.32	Kw/h	295.68	Kw.	165.88		177.72				1903.26	2039.21
		Electrical Welding	11	4	28	8	896		11	Kw/h	13.20	Kw/h	11827.20	Kw.	6635.06		7108.99				76130.50	81568.40
		Steel cutting	2	4	28	5	560		2	Kw/h	2.40	Kw/h	1344.00	Kw.	753.98		807.84				8651.19	9269.14
8. Wiring System	20	Site elevator	66	2	10	4	80		66	Kw/h	79.20	Kw/h	6336.00	Kw.	3554.50	3554.50	5331.74	5331.74			40784.20	43697.36
		Truck with crane																				
9. Electrical Supply	15	Site elevator	66	2	15	2	60		66	Kw/h	79.20	Kw/h	4752.00	Kw.	2665.87	2665.87	5331.74	5331.74			30588.15	61176.30
10. Fire alarm system	9	Tower crane	75	1	3	2	6		75	Kw/h	90.00	Kw/h	540.00	Kw.	302.94	2646.00	1009.80	8820.00			3475.93	11586.42
		Electrical welding	11	4	9	8	288		11	Kw/h	13.20	Kw/h	3801.60	Kw.	2132.70		7108.99				24470.52	81568.40
		Steel cutting	2	1	9	8	72		2	Kw/h	2.40	Kw/h	172.80	Kw.	96.94		323.14				1112.30	3707.65
		Impact drilling	0.78	4	9	6	216		0.78	Kw/h	0.94	Kw/h	202.18	Kw.	113.42		378.07				1301.39	4337.96

Table A.16 The project data collection for monthly record at 16 : April 25 – May 25, 2011.

Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
April 25 – May 25, 2011 (29 Days)																						
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	13	Back hoe	99	1	13	8	104		6	L/h	7.20	L/h	748.80	L	1063.69	2881.33	2454.68	6649.23	22037.18	132223.08		
		Tower crane	75	1	6	6	36		75	Kw/h	90.00	Kw/h	3240.00	Kw.	1817.64		4194.55				20855.56	48128.21
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	29	Site elevator	66	2	29	10	580		66	Kw/h	79.20	Kw/h	45936.00	Kw.	25770.10	25770.10	26658.72	26658.72			295685.44	305881.49
Architectural Activities																						
1. Masonry work	29	Tower crane	75	2	29	3	174		75	Kw/h	90.00	Kw/h	15660.00	Kw.	8785.26	8785.26	9088.20	9088.20			100801.85	104277.78
2. Rendering work	29	Tower crane	75	2	29	3	174		75	Kw/h	90.00	Kw/h	15660.00	Kw.	8785.26	8785.26	9088.20	9088.20			100801.85	104277.78
3. Ceiling work	20	Site elevator	66	2	20	5	200		66	Kw/h	79.20	Kw/h	15840.00	Kw.	8886.24	9222.30	13329.36	13833.45			101960.50	152940.74
		Impact drilling	0.78	4	20	8	640		0.78	Kw/h	0.94	Kw/h	599.04	Kw.	336.06		504.09				3855.96	5783.94
4. Doors and windows work	15	Site elevator	66	2	15	5	150		66	Kw/h	79.20	Kw/h	11880.00	Kw.	6664.68	6894.41	13329.36	13788.82			76470.37	152940.74
		Electric drilling	0.65	5	15	7	525		0.65	Kw/h	0.78	Kw/h	409.50	Kw.	229.73		459.46				2635.91	5271.82
5. Sanitary and hygiene fitting	8	Site elevator	66	2	8	3	48		66	Kw/h	79.20	Kw/h	3801.60	Kw.	2132.70	2132.70	7997.62	7997.62			24470.52	91764.45
6. Painting work	29	Site elevator	66	2	8	3	48		66	Kw/h	79.20	Kw/h	3801.60	Kw.	2132.70	2132.70	2206.24	2206.24			24470.52	25314.33
7. Topping covering work	15	Site elevator	66	2	10	3	60		66	Kw/h	79.20	Kw/h	4752.00	Kw.	2665.87	2665.87	5331.74	5331.74			30588.15	61176.30
8. Tile, floor and terrazzo work	29	Site elevator	66	2	20	3	120		66	Kw/h	79.20	Kw/h	9504.00	Kw.	5331.74	5331.74	5515.60	5515.60			61176.30	63285.83
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	28	Site elevator	66	1	28	6	168		66	Kw/h	79.20	Kw/h	13305.60	Kw.	7464.44	7464.44	7997.62	7997.62			8566.82	91764.45
3. Cold Water System	14	Tower crane	75	1	6	2	12		75	Kw/h	90.00	Kw/h	1080.00	Kw.	605.88	4360.72	1298.31	9344.40			6951.85	14896.83
		PPR Welding	0.80	1	14	8	112		0.80	Kw/h	0.96	Kw/h	107.52	Kw.	60.32		129.25				692.10	1483.06
		Electrical Welding	11	4	14	8	448		11	Kw/h	13.20	Kw/h	5913.60	Kw.	3317.53		7108.99				38065.25	81568.40
		Steel cutting	2	4	14	5	280		2	Kw/h	2.40	Kw/h	672.00	Kw.	376.99		807.84				4325.60	9269.14
4. Waste Water System	14	Tower crane	75	1	6	2	12		75	Kw/h	90.00	Kw/h	1080.00	Kw.	605.88	4383.34	1298.31	9392.87			6951.85	14869.86
		PPR Welding	1.10	1	14	8	112		1.10	Kw/h	1.32	Kw/h	147.84	Kw.	82.94		177.72				951.63	2039.21
		Electrical Welding	11	4	14	8	448		11	Kw/h	13.20	Kw/h	5913.60	Kw.	3317.53		7108.99				38065.25	81568.40
		Steel cutting	2	4	14	5	280		2	Kw/h	2.40	Kw/h	672.00	Kw.	376.99		807.84				4325.60	9269.14
5. Vent System	14	Tower crane	75	1	6	2	12		75	Kw/h	90.00	Kw/h	1080.00	Kw.	605.88	4383.34	1298.31	9392.87			6951.85	14869.86
		PPR Welding	1.10	1	14	8	112		1.10	Kw/h	1.32	Kw/h	147.84	Kw.	82.94		177.72				951.63	2039.21
		Electrical Welding	11	4	14	8	448		11	Kw/h	13.20	Kw/h	5913.60	Kw.	3317.53		7108.99				38065.25	81568.40
		Steel cutting	2	4	14	5	280		2	Kw/h	2.40	Kw/h	672.00	Kw.	376.99		807.84				4325.60	9269.14
6. Soil System	14	Tower crane	75	1	6	2	12		75	Kw/h	90.00	Kw/h	1080.00	Kw.	605.88	4383.34	1298.31	9392.87			6951.85	14869.86
		PPR Welding	1.10	1	14	8	112		1.10	Kw/h	1.32	Kw/h	147.84	Kw.	82.94		177.72				951.63	2039.21
		Electrical welding	11	4	14	8	448		11	Kw/h	13.20	Kw/h	5913.60	Kw.	3317.53		7108.99				38065.25	81568.40
		Steel cutting	2	4	14	5	280		2	Kw/h	2.40	Kw/h	672.00	Kw.	376.99		807.84				4325.60	9269.14
7. Storm Drainage System	14	Tower crane	75	1	6	2	12		75	Kw/h	90.00	Kw/h	1080.00	Kw.	605.88	4383.34	1298.31	9392.87			6951.85	14869.86
		PPR Welding	1.10	1	14	8	112		1.10	Kw/h	1.32	Kw/h	147.84	Kw.	82.94		177.72				951.63	2039.21
		Electrical Welding	11	4	14	8	448		11	Kw/h	13.20	Kw/h	5913.60	Kw.	3317.53		7108.99				38065.25	81568.40
		Steel cutting	2	4	14	5	280		2	Kw/h	2.40	Kw/h	672.00	Kw.	376.99		807.84				4325.60	9269.14
8. Wiring System	27	Site elevator	66	1	15	8	120		66	Kw/h	79.20	Kw/h	9504.00	Kw.	5331.74	5331.74	5924.16	5924.16			61176.30	131092.07
		Truck with crane																				
9. Electrical Supply	13	Site elevator	66	1	13	2	26		66	Kw/h	79.20	Kw/h	2059.20	Kw.	1155.21	1155.21	2665.87	2665.87			13254.86	30588.15
10. Fire alarm system	29	Tower crane	75	1	13	2	26		75	Kw/h	90.00	Kw/h	2340.00	Kw.	1312.74	8862.60	1358.01	9168.20			15062.35	15581.74
		Electrical welding	11	4	29	8	928		11	Kw/h	13.20	Kw/h	12249.60	Kw.	6872.03		7108.99				78849.45	81568.40
		Steel cutting	2	1	29	8	232		2	Kw/h	2.40	Kw/h	556.80	Kw.	312.36		323.14				3584.07	3707.65
		Impact drilling	0.78	4	29	6	696		0.78	Kw/h	0.94	Kw/h	651.46	Kw.	365.47		378.07				4193.36	4337.96

Table A.17 The project data collection for monthly record at 17 : May 26 - June 25, 2011.

May 26 - June 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	3	Back hoe	99	1	3	8	24		6	L/h	7.20	L/h	172.80	L	245.47	245.47	2454.68	2454.68	5085.50	50855.04		
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	30	Site elevator	66	1	30	8	240		66	Kw/h	79.20	Kw/h	19008.00	Kw.	10663.49	10663.49	10663.49	10663.49			122352.60	122352.60
Architectural Activities																						
1. Masonry work	26	Tower crane	75	2	26	3	156		75	Kw/h	90.00	Kw/h	14040.00	Kw.	7876.44	7876.44	9088.20	9088.20			90374.08	104277.78
2. Rendering work	26	Tower crane	75	2	26	3	156		75	Kw/h	90.00	Kw/h	14040.00	Kw.	7876.44	7876.44	9088.20	9088.20			90374.08	104277.78
3. Ceiling work	30	Site elevator	66	2	30	5	300		66	Kw/h	79.20	Kw/h	1+23760.00	Kw.	13329.36	13833.45	13329.36	13833.45			152940.74	152940.74
		Impact drilling	0.78	4	30	8	960		0.78	Kw/h	0.94	Kw/h	898.56	Kw.	504.09		504.09				5783.94	5783.94
4. Doors and windows work	10	Site elevator	66	1	10	6	60		66	Kw/h	79.20	Kw/h	4752.00	Kw.	2665.87	2819.03	7997.62	8457.08			30588.15	91764.45
		Electric drilling	0.65	5	10	7	350		0.65	Kw/h	0.78	Kw/h	273.00	Kw.	153.15		459.46				1757.27	5271.82
5. Sanitary and hygiene fitting	18	Site elevator	66	2	18	4	144		66	Kw/h	79.20	Kw/h	11404.80	Kw.	6398.09	6398.09	10663.49	10663.49			73411.56	122352.60
6. Painting work	6	Site elevator	66	1	3	3	9		66	Kw/h	79.20	Kw/h	712.80	Kw.	399.88	399.88	1999.40	1999.40			4588.22	22941.11
7. Topping covering work	3	Site elevator	66	1	3	2	6		66	Kw/h	79.20	Kw/h	475.20	Kw.	266.59	266.59	2665.87	2665.87			3058.81	30588.15
8. Tile, floor and terrazzo work	30	Site elevator	66	2	30	3	180		66	Kw/h	79.20	Kw/h	14256.00	Kw.	7997.62	7997.62	7997.62	7997.62			91764.45	91764.45
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	28	Site elevator	66	1	28	6	168		66	Kw/h	79.20	Kw/h	13305.60	Kw.	7464.44	7464.44	7997.62	7997.62			85646.82	91764.45
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System	18	Site elevator	66	1	10	3	30		66	Kw/h	79.20	Kw/h	2376.00	Kw.	1332.94	1332.94	2221.56	2221.56			15294.07	25490.12
		Truck with crane																				
9. Electrical Supply	14	Site elevator	66	1	14	3	42		66	Kw/h	79.20	Kw/h	3326.40	Kw.	1866.11	1866.11	3998.81	3998.81			21411.70	45882.22
10. Fire alarm system	12	Tower crane	75	1	5	2	10		75	Kw/h	90.00	Kw/h	900.00	Kw.	504.90	3628.98	1262.25	9072.45			5793.21	14483.03
		Electrical welding	11	4	12	8	384		11	Kw/h	13.20	Kw/h	5068.80	Kw.	2843.60		7108.99				32627.36	81568.40
		Steel cutting	2	1	12	8	96		2	Kw/h	2.40	Kw/h	230.40	Kw.	129.25		323.14				1483.06	3707.65
		Impact drilling	0.78	4	12	6	288		0.78	Kw/h	0.94	Kw/h	269.57	Kw.	151.23		378.07				1735.18	4337.96

Table A.18 The project data collection for monthly record at 18 : June 26 - July 25, 2011.

June 26 - July 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	8	Back hoe	99	1	8	8	64		6	L/h	7.20	L/h	460.80	L	654.58	654.58	2454.68	2454.68	13561.34	50855.04		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	24	Back hoe	99	1	24	8	192		6	L/h	7.20	L/h	1382.40	L	1963.74	4488.24	2454.68	5610.30	40684.03	50855.04		
		Tower crane	75	1	10	5	50		75	Kw/h	90.00	Kw/h	4500.00	Kw.	2524.50		3155.63				28966.05	36207.56
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	30	Site elevator	66	1	30	8	240		66	Kw/h	79.20	Kw/h	19008.00	Kw.	10663.49	10663.49	10663.49	10663.49			122352.60	122352.60
Architectural Activities																						
1. Masonry work	16	Tower crane	75	1	16	3	48		75	Kw/h	90.00	Kw/h	4320.00	Kw.	2423.52	2423.52	4544.10	4544.10			27807.41	52138.89
2. Rendering work	18	Tower crane	75	1	18	3	54		75	Kw/h	90.00	Kw/h	4860.00	Kw.	2726.46	2726.46	4544.10	4544.10			31283.33	52138.89
3. Ceiling work	28	Site elevator	66	1	28	6	168		66	Kw/h	79.20	Kw/h	13305.60	Kw.	7464.44	7934.93	7997.62	8501.71			85646.82	91764.45
		Impact drilling	0.78	4	28	8	896		0.78	Kw/h	0.94	Kw/h	838.66	Kw.	470.9		504.09				5398.34	5783.94
4. Doors and windows work	10	Site elevator	66	1	10	6	60		66	Kw/h	79.20	Kw/h	4752.00	Kw.	2665.87	2819.03	7997.62	8457.08			30588.15	91764.45
		Electric drilling	0.65	5	10	7	360		0.65	Kw/h	0.78	Kw/h	273.00	Kw.	153.15		49.46				1757.27	5271.82
5. Sanitary and hygiene fitting	9	Site elevator	66	1	9	3	27		66	Kw/h	79.20	Kw/h	2138.40	Kw.	1199.64	1199.64	3998.81	3998.81			13764.67	45882.22
6. Painting work	22	Site elevator	66	1	18	4	72		66	Kw/h	79.20	Kw/h	5702.40	Kw.	3199.05	3199.05	4362.34	4362.34			36705.78	50053.33
7. Topping covering work	4	Site elevator	66	1	4	2	8		66	Kw/h	79.20	Kw/h	633.60	Kw.	355.45	355.45	2665.87	2665.87			4078.42	30588.15
8. Tile, floor and terrazzo work	30	Site elevator	66	1	30	4	120		66	Kw/h	79.20	Kw/h	9504.00	Kw.	5331.74	5331.74	5331.74	5331.74			61176.30	61176.30
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	4	Site elevator	66	1	4	3	12		66	Kw/h	79.20	Kw/h	950.40	Kw.	533.17	533.17	3998.81	3998.81			6117.63	45882.22
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		steel Cutting																				
		Impact drilling																				

Table A.19 The project data collection for monthly record at 19 : July 26 - August 25, 2011.

July 26 - August 25, 2011 (31 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	19	Back hoe	99	1	8	8	64		8	L/h	7.20	L/h	460.80	L	654.58	654.58	1033.55	1033.55	13561.34	21412.65		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	10	Back hoe	99	1	10	8	80		6	L/h	7.20	L/h	576.00	L	818.23	1575.58	2454.68	4726.73	16951.68	50855.04		
		Tower crane	75	1	3	5	15		75	Kw/h	90.00	Kw/h	1350.00	Kw.	757.35		2272.05				8689.82	26069.45
10. Roads and surrounding ground	5	Back hoe	99	1	1	8	8		6	L/h	7.20	L/h	57.60	L	81.82	627.91	490.94	3769.94	1695.17	10171.01		
		Rolling compactor	93	1	5	8	40		8	L/h	9.60	L/h	384.00	L	545.48		3272.90		11301.12	67806.72		
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	31	Site elevator	66	1	31	8	248		66	Kw/h	79.20	Kw/h	19641.60	Kw.	11018.94	11018.94	10663.49	10663.49			126431.02	122352.60
Architectural Activities																						
1. Masonry work	17	Tower crane	75	1	17	3	51		75	Kw/h	90.00	Kw/h	4590.00	Kw.	2574.99	2574.99	4544.10	4544.10			29545.37	62138.89
2. Rendering work	26	Tower crane	75	1	2	3	78		75	Kw/h	90.00	Kw/h	7020.00	Kw.	3938.22	3938.22	4544.10	4544.10			45187.04	62138.89
3. Ceiling work	2	Site elevator	66	1	25	6	150		66	Kw/h	79.20	Kw/h	11880.00	Kw.	6664.68	6874.72	7997.62	8249.65			76470.37	91764.45
		Impact drilling	0.78	2	25	8	400		0.78	Kw/h	0.94	Kw/h	374.40	Kw.	210.04		252.05				2409.98	2891.97
4. Doors and windows work	18	Site elevator	66	1	18	6	108		66	Kw/h	9.20	Kw/h	8553.60	Kw.	4798.57	5074.25	7997.62	8457.08			55058.67	91764.45
		Electric drilling	0.65	5	18	7	630		0.65	Kw/h	0.78	Kw/h	491.40	Kw.	275.68		459.46				3163.09	5271.82
5. Sanitary and hygiene fitting	4	Site elevator	66	1	4	3	12		66	Kw/h	79.20	Kw/h	950.40	Kw.	533.17	533.17	3998.81	3998.81			6117.63	45882.22
6. Painting work	20	Site elevator	66	1	16	2	32		66	Kw/h	79.20	Kw/h	2534.40	Kw.	1421.80	1421.80	2132.70	2132.70			16313.68	24470.52
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work	10	Site elevator	66	1	6	3	18		66	Kw/h	79.20	Kw/h	125.60	Kw.	799.76	799.76	2399.28	2399.28			9076.44	27529.33
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	4	Site elevator	66	1	4	3	12		66	Kw/h	79.20	Kw/h	950.40	Kw.	533.17	533.17	3998.81	3998.81			6117.63	45882.22
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.20 The project data collection for monthly record at 20 : August 26 – September 25, 2011.

August 26 – September 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work	10	Back hoe	99	1	10	8	80		6	L/h	7.20	L/h	576.00	L	818.23	818.23	2454.68	2454.68	16951.68	50855.04		
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work	10	Back hoe	99	1	10	8	80		6	L/h	7.20	L/h	576.00	L	818.23	1828.03	2454.68	5484.08	16951.68	50855.04		
		Tower crane	75	1	4	5	20		75	Kw/h	90.00	Kw/h	1800.00	Kw.	1009.80		3029.40				11586.42	34759.26
10. Roads and surrounding ground	5	Back hoe														354.88		2129.29				
		Rolling compactor																				
		Concrete truck	820	16	2	3	96		3	Km./l	2.40	Km./l	200.00	L	284.11		1704.64		5886.00	35316.00		
		Concrete vibrator	3.60	6	2	2	24		1.73	L/h	2.08	L/h	49.82	L	70.78		424.66		1706.47	10238.83		
11. Labors and material transport	30	Site elevator	66	1	30	8	240		66	Kw/h	79.20	Kw/h	19008.00	Kw.	10663.49	10663.49	10663.49	10663.49			122352.60	122352.60
Architectural Activities																						
1. Masonry work	10	Tower crane	75	1	10	3	30		75	Kw/h	90.00	Kw/h	2700.00	Kw.	1514.70	1514.70	4544.10	4544.10			17379.63	52138.89
2. Rendering work	14	Tower crane	75	1	14	3	42		75	Kw/h	90.00	Kw/h	3780.00	Kw.	5120.58	5120.58	4544.10	4544.10			24331.48	52138.89
3. Ceiling work	21	Site elevator	66	1	21	4	84		66	Kw/h	79.20	Kw/h	6652.80	Kw.	3732.22	4085.09	5331.74	5835.84			42823.41	61176.30
		Impact drilling	0.78	4	21	8	672		0.78	Kw/h	0.94	Kw/h	628.99	Kw.	352.86		504.09				4048.76	5783.94
4. Doors and windows work	10	Site elevator	66	1	10	4	40		66	Kw/h	79.20	Kw/h	3168.00	Kw.	1777.25	1930.40	5331.74	5791.20			20392.10	61176.30
		Electric drilling	0.65	5	10	7	350		0.65	Kw/h	0.78	Kw/h	273.00	Kw.	153.15		459.46				1757.27	5271.82
5. Sanitary and hygiene fitting	3	Site elevator	66	1	3	3	9		66	Kw/h	79.20	Kw/h	712.80	Kw.	399.88	399.88	3998.81	3998.81			4588.22	45882.22
6. Painting work	15	Site elevator	66	1	7	3	21		66	Kw/h	79.20	Kw/h	1663.20	Kw.	933.05	933.05	1866.11	1866.11			10705.85	21411.70
7. Topping covering work	1	Site elevator	66	1	1	3	3		66	Kw/h	79.20	Kw/h	237.60	Kw.	133.29	133.29	3998.81	3998.81			1529.41	45882.22
8. Tile, floor and terrazzo work	20	Site elevator	66	1	15	4	60		66	Kw/h	79.20	Kw/h	4752.00	Kw.	2665.87	2665.87	3998.81	3998.81			30588.15	45882.22
System Activities																						
1. Elevator system	7	Tower crane	75	1	7	3	21		75	Kw/h	90.00	Kw/h	1890.00	Kw.	1060.29	1060.29	4544.10	4544.10			12165.74	52138.89
2. Air-conditioning system	2	Site elevator	66	1	2	3	6		66	Kw/h	79.20	Kw/h	475.20	Kw.	266.59	266.59	3998.81	3998.81			3058.81	45882.22
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.21 The project data collection for monthly record at 21 : September 26 - October 25, 2011.

September 26 - October 25, 2011 (29 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO_2 kg	Total CO_2 kg	CO_2 (kg./Month)	Total CO_2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport	29	Site elevator	66	1	29	8	232		66	Kw/h	79.20	Kw/h	18374.40	Kw.	10308.04	10308.04	10663.49	10663.49			118274.18	122352.60
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work	16	Site elevator	66	1	8	3	24		66	Kw/h	79.20	Kw/h	1900.80	Kw.	1066.35	1066.35	1999.40	1999.40			12235.26	22941.11
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system	66	Site elevator	66	1	14	4	56		66	Kw/h	79.20	Kw/h	4435.20	Kw.	2488.15	2488.15	5331.74	5331.74			28548.94	61176.30
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

Table A.22 The project data collection for monthly record at 22 : October 26 - November 25, 2011.

October 26 - November 25, 2011 (30 Days)																						
Activities	Days	Equipments	Power (Kw)	No. of Equipment	Working Time (day)	Working Time (hr/day)	Total Working Time (hr.)	Total Distances (km)	Oil fuel	Units	Efficiency 80 %	Units	Total Fuel Consumption	Units	CO2 kg	Total CO2 kg	CO2 (kg./Month)	Total CO2 (kg./Month)	Fuel Cost (Bath)	Fuel Cost (Bath/Month)	Electricity Charge (Bath)	Electricity Charge (Bath/Month)
Structural Activities																						
1. Site preparation		Back hoe																				
		Dump truck																				
2. Pilling work		Back hoe																				
		Generator																				
		Drilling rig crane																				
		Mobile crane																				
3. Excavation work		Back hoe																				
4.Foundation		Back hoe																				
		Generator																				
		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Demolition hammer																				
		Concrete vibrator																				
5.Floor work																						
5.1 Scaffolding		Tower crane																				
		Truck with crane																				
5.2 Wooden formwork structure		Tower crane																				
		Truck with crane																				
5.3 Post tension slab work		Tower crane																				
		Concrete truck																				
		Mobile pump																				
		Concrete vibrator																				
5.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
5.5 Steel form demolition work		Tower crane																				
6. Colum work																						
6.1 Scaffolding		Tower crane																				
		Truck with crane																				
6.2 Steel form work		Tower crane																				
		Truck with crane																				
6.3 Concrete placing work		Tower crane																				
		Truck with crane																				
		Mobile pump																				
		Concrete vibrator																				
6.4 Reinforcing work		Tower crane																				
		Truck with crane																				
		Steel cutting																				
6.5 Steel form demolition work		Tower crane																				
7. Precast installation		Tower crane																				
		Trailer																				
8. Water tanks on the property		Tower crane																				
		Concrete truck																				
		Concrete vibrator																				
9. Pipelines and utilities work		Back hoe																				
		Tower crane																				
10. Roads and surrounding ground		Back hoe																				
		Rolling compactor																				
		Concrete truck																				
		Concrete vibrator																				
11. Labors and material transport		Site elevator																				
Architectural Activities																						
1. Masonry work		Tower crane																				
2. Rendering work		Tower crane																				
3. Ceiling work		Site elevator																				
		Impact drilling																				
4. Doors and windows work		Site elevator																				
		Electric drilling																				
5. Sanitary and hygiene fitting		Site elevator																				
6. Painting work	12	Site elevator	66	1	10	3	30		66	Kw/h	79.20	Kw/h	2376.00	Kw.	1332.94	1332.94	3332.34	3332.34			15294.07	38235.19
7. Topping covering work		Site elevator																				
8. Tile, floor and terrazzo work		Site elevator																				
System Activities																						
1. Elevator system		Tower crane																				
2. Air-conditioning system		Site elevator																				
3. Cold Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
4. Waste Water System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
5. Vent System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
6. Soil System		Tower crane																				
		PPR Welding																				
		Electrical welding																				
		Steel cutting																				
7. Storm Drainage System		Tower crane																				
		PPR Welding																				
		Electrical Welding																				
		Steel cutting																				
8. Wiring System		Site elevator																				
		Truck with crane																				
9. Electrical Supply		Site elevator																				
10. Fire alarm system		Tower crane																				
		Electrical welding																				
		Steel cutting																				
		Impact drilling																				

APPENDIX B

CO_2 Emission Estimation of Heavy Equipments Before Cleaner Technology Application

Before Cleaner Technology Application

Table B.1 : CO_2 emission estimation from Excavator (Back hoe).

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	46.00	5,299.20	7,527.68
2	38.00	4,377.60	6,218.51
3	34.00	3,916.80	5,563.93
4	14.00	1,612.80	2,291.03
5	3.00	345.60	490.94
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	25.00	1,440.00	2,045.56
11	30.00	1,728.00	2,454.67
12	26.00	1,497.60	1,718.27
13	21.00	1,209.60	1,718.27
14	15.00	864.00	1,227.34
15	10.00	576.00	818.22
16	13.00	748.80	1,063.69
17	3.00	172.80	245.47
18	32.00	1,843.20	2,618.32
19	19.00	1,094.40	1,554.63
20	20.00	1,152.00	1,636.46
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	349	27,878.40	39,192.99

Table B.2 : CO_2 emission estimation from Generator.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	5,803.20	8,243.62
2	28.00	5,241.60	7,445.85
3	30.00	5,616.00	7,977.70
4	14.00	2,620.80	3,722.93
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	103	19,281.60	27,390.10

Table B.3 : CO_2 emission estimation from Drilling rig crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	1,860.00	2,642.19
2	28.00	1,680.00	2,386.49
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	59	3,540	5,029.68

Table B.4 : CO_2 emission estimation from Mobile crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	1,785.60	2,536.50
2	28.00	1,612.80	2,291.03
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	59	3,398.40	4,827.53

Table B.5 : CO_2 emission estimation from Concrete truck.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	33.00	2,937.50	4,172.70
4	21.00	1,213.66	1,13.99
5	6.00	1,312.50	1,994.75
6	14.00	1,835.00	2,521.44
7	12.00	1,800.00	2,556.96
8	10.00	1,350.00	1,917.72
9	12.00	1,762.50	2,503.69
10	12.00	1,762.50	2,503.69
11	8.00	1,325.00	1,882.21
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	2.00	200.00	284.11
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	2.00	200.00	284.11
21	0.00	0.00	0.00
22	0.00	0.00	0.00
∑	132	15,698.66	21,935.37

Table B.6 : CO_2 emission estimation from Mobile concrete pump.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	33.00	1,829.52	2,598.89
4	14.00	776.16	1,102.56
5	6.00	517.44	735.03
6	6.00	554.40	787.54
7	8.00	443.52	630.03
8	7.00	258.72	367.52
9	8.00	443.52	630.03
10	8.00	739.20	1,050.06
11	6.00	665.28	945.05
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	96	6,227.76	8,846.71

Table B.7 : CO_2 emission estimation from Truck with crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	8.00	114.75	163.00
4	5.00	28.13	39.95
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	2.00	18.75	26.63
9	1.00	18.75	26.63
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	16	180.38	256.21

Table B.8 : CO_2 emission estimation from Trailer.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	27.00	1,687.50	2,397.14
8	21.00	1,281.25	1,820.05
9	27.00	1,687.50	2,397.14
10	27.00	1,687.50	2,397.14
11	14.00	843.75	1,198.57
12	20.00	1,250.00	1,775.66
13	18.00	1,125.00	1,598.10
14	15.00	937.50	1,131.75
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	169	10,500	14,715.55

Table B.9 : CO_2 emission estimation from Rolling compactor.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	5.00	336.00	477.30
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	5.00	384.00	545.48
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	10	720	1,022.78

Table B.10 : CO_2 emission estimation from Tower crane.

Month	Working Time (Days)	Total Fuel Consumption (Kilowatts)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	47.00	15,8401.00	8,885.80
5	37.00	13,590.00	6,715.44
6	47.00	17,460.00	9,795.06
7	88.00	91,350.00	54,478.71
8	113.00	55,980.00	31,404.78
9	161.00	84,060.00	188,005.66
10	186.00	106,300.00	59,073.30
11	188.00	90,342.00	50,238.54
12	151.00	82,440.00	144,772.20
13	117.00	54,657.00	30,596.94
14	133.00	66,960.00	37,564.55
15	128.00	56,190.00	31,354.29
16	107.00	51,911.00	23,730.30
17	57.00	28,980.00	45,237.78
18	44.00	13,680.00	7,674.48
19	46.00	12,960.00	7,270.56
20	35.00	10,170.00	5,705.37
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	1,685	995,431	742,503.76

Table B.11 : CO_2 emission estimation from Site elevator.

Month	Working Time (Days)	Total Fuel Consumption (Kilowatts)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	36.00	51,004.80	28,613.70
10	34.00	49,579.20	27,813.93
11	43.00	46,728.00	26,214.41
12	94.00	72,784.80	48,829.89
13	90.00	35,164.80	19,727.44
14	163.00	58,053.60	34,967.36
15	148.00	113,569.20	63,714.34
16	166.00	120,384.00	67,535.42
17	176.00	93,376.80	52,386.39
18	137.00	55,994.40	31,412.85
19	104.00	46,036.00	25,870.09
20	89.00	36,758.60	20,571.65
21	51.00	24,710.40	13,862.54
22	40.00	21,384.00	11,996.43
$\sum$	1,371	825,528.60	473,516.44

Table B.12 : CO_2 emission estimation from Dump truck.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	7	19.69	27.97
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	7	19.69	27.97

APPENDIX C

CO_2 Emission Estimation of Heavy Equipments After Cleaner Technology Application

After Cleaner Technology Application

Table C.1 : CO_2 emission estimation from Excavator (Back hoe).

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	46.00	4,190.40	5,952.59
2	38.00	3,427.20	4,868.44
3	34.00	3,042.80	4,336.59
4	14.00	1,080.00	1,431.89
5	3.00	216.00	306.83
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	25.00	1,080.00	1,534.17
11	30.00	1,116.00	1,585.31
12	26.00	936.00	1,329.62
13	21.00	756.00	1,073.93
14	15.00	540.00	767.09
15	10.00	360.00	511.40
16	13.00	468.00	664.81
17	3.00	108.00	153.42
18	24.00	1,036.80	1,472.81
19	19.00	813.60	1,155.75
20	20.00	720.00	1,022.78
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	341	19,890.80	28,167.43

Table C.2 : CO_2 emission estimation from Generator.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	4,352.40	6,182.71
2	28.00	3,931.20	5,584.39
3	30.00	4,215.00	5,983.27
4	14.00	1,965.60	2,792.19
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	103	14,464.20	20,542.56

Table C.3 : CO_2 emission estimation from Drilling rig crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	1,395.00	1,981.64
2	28.00	1,470.00	2,088.18
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	59	2,865	4,069.82

Table C.4 : CO_2 emission estimation from Mobile crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	31.00	1,116.00	1,585.31
2	28.00	1,411.20	2,004.65
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	59	2,527.20	3,589.96

Table C.5 : CO_2 emission estimation from Concrete truck.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	33.00	2,220.00	3,153.58
4	21.00	930.00	1,321.10
5	6.00	975.00	1,385.01
6	10.00	1,320.00	1,875.10
7	12.00	1,320.00	1,875.10
8	10.00	1,005.00	1,427.63
9	12.00	1,320.00	1,875.10
10	12.00	1,320.00	1,875.10
11	8.00	990.00	1,406.33
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	2.00	120.00	170.46
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	2.00	150.00	213.08
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	128	11,670	16,577.59

Table C.6 : CO_2 emission estimation from Mobile concrete pump.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	33.00	1,829.52	2,598.89
4	14.00	776.16	1,102.56
5	6.00	909.84	866.29
6	7.00	776.16	1,102.56
7	8.00	443.52	603.03
8	7.00	258.72	367.52
9	8.00	443.52	630.03
10	8.00	295.68	420.02
11	6.00	332.64	472.53
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	97	6,065.73	8,163.43

Table C.7 : CO_2 emission estimation from Truck with crane.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	8.00	114.75	163.00
4	5.00	23.44	33.30
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	2.00	18.75	26.63
9	1.00	18.75	26.63
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	16	175.69	249.56

Table C.8 : CO_2 emission estimation from Trailer.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	27.00	1,687.50	2,397.14
8	21.00	1,281.25	1,820.05
9	27.00	1,687.50	2,397.14
10	27.00	1,687.50	2,397.14
11	14.00	843.75	1,198.57
12	20.00	1,250.00	1,775.66
13	18.00	1,125.00	1,598.10
14	15.00	937.50	1,131.75
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	169	10,500	14,715.55

Table C.9 : CO_2 emission estimation from Rolling compactor.

Month	Working Time (Days)	Total Fuel Consumption (Litres)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	5.00	252.00	357.97
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	5.00	336.00	477.30
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	10	588	835.27

Table C.10 : CO_2 emission estimation from Tower crane.

Month	Working Time (Days)	Total Fuel Consumption (Kilowatts)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	47.00	15,120.00	8,482.32
5	32.00	10,260.00	5,654.88
6	49.00	13,680.00	7,674.48
7	86.00	52,290.00	29,334.69
8	113.00	49,410.00	27,719.01
9	161.00	74,098.94	41,401.80
10	186.00	89,035.20	49,884.12
11	182.00	82,530.00	46,299.33
12	151.00	79,740.00	44,734.14
13	117.00	54,540.00	30,596.94
14	133.00	51,630.12	37,564.56
15	128.00	55,890.00	31,354.29
16	107.00	41,760.00	23,427.36
17	57.00	28,980.00	16,257.78
18	44.00	13,680.00	7,674.48
19	46.00	12,960.00	7,270.56
20	35.00	10,170.00	5,705.37
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	1,674	735,774.26	421,036.11

Table C.11 : CO_2 emission estimation from Site elevator.

Month	Working Time (Days)	Total Fuel Consumption (Kilowatts)	CO_2 emission (kg.)
1	0.00	0.00	0.00
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	36.00	31,838.45	17,861.35
10	34.00	30,254.40	16,972.72
11	43.00	31,759.20	17,816.91
12	94.00	69,616.00	39,055.02
13	120.00	56,627.20	31,768.29
14	163.00	52,034.40	29,191.29
15	148.00	86,971.60	48,785.44
16	166.00	93,060.00	52,206.66
17	176.00	83,081.80	46,608.34
18	133.00	49,024.80	27,502.90
19	104.00	36,194.40	20,305.05
20	89.00	29,066.40	16,306.26
21	51.00	20,116.00	11,285.53
22	40.00	16,632.00	9,330.56
$\sum$	1,397	686,276.65	384,996.32

Table C.12 : CO_2 emission estimation from Dump truck.

Month	Working Time (Days)	Total Fuel Consumption (Kilowatts)	CO_2 emission (kg.)
1	7	19.69	27.97
2	0.00	0.00	0.00
3	0.00	0.00	0.00
4	0.00	0.00	0.00
5	0.00	0.00	0.00
6	0.00	0.00	0.00
7	0.00	0.00	0.00
8	0.00	0.00	0.00
9	0.00	0.00	0.00
10	0.00	0.00	0.00
11	0.00	0.00	0.00
12	0.00	0.00	0.00
13	0.00	0.00	0.00
14	0.00	0.00	0.00
15	0.00	0.00	0.00
16	0.00	0.00	0.00
17	0.00	0.00	0.00
18	0.00	0.00	0.00
19	0.00	0.00	0.00
20	0.00	0.00	0.00
21	0.00	0.00	0.00
22	0.00	0.00	0.00
$\sum$	7	19.69	27.97

BIOGRAPHY

Mr. Thanikun Padthayanan was born on January 17, 1986 in Bangkok, the capital city of Thailand. He was graduated from high school of Suankularb Wittayalai school. He started to study in Department of Civil Engineering at Sirindtorn International Institute of Technology (SIIT), Thamasat University in 2006 and graduated the Bachelor degree of Civil Engineering in 2010. Thereafter, he continued his further education in Master degree of Infrastructure Engineering at the Department of Civil Engineering, Chulalongkorn University, Thailand.