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A

THESIS REPORT

ON

WASTE RECYCLING CENTER

For Kathmandu Metropolitan City

SUBMITTED BY:

MANISHA SHRESTHA

074BAE218

A THESIS SUBMITTED TO

DEPARTMENT OF ARCHITECTURE

IN PARTIAL FULFILLMENT OF THE REQUIREMENT OF

THE DEGREE OF BACHELOR IN ARCHITECTURE

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CERTIFICATE

This is to certify that this thesis entitled "WASTE RECYCLING CENTER for Kathmandu Metropolitan City" at Teku, Kathmandu, submitted by Ms. Manisha Shrestha has been examined and has been declared successful for the partial fulfillment of the academic requirement for the completion of the Degree of Bachelor of Architecture.

....

Asst. Prof. Prajwal Hada

(Thesis Supervisor)

Date: ....

Department of Architecture

Pulchowk Campus,

Institute of Engineering

Pulchowk, Lalitpur

DECLARATION

I declare that this dissertation is my original, unaided work, completed exclusively by me under the supervision of Asst. Prof. Prajwal Hada. This document is required for the bachelor's degree in Architecture at Tribhuvan University. It has never been submitted for a degree at any another university. Thus, except where otherwise stated, I declare that this dissertation is the result of my own independent investigation/work. I hereby grant consent for my dissertation, if accepted, to be photocopied and understand that any reference to or quotation from my thesis will be acknowledged.

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Manisha Shrestha

(074-BAE-218)

Date: ....

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Sincerely,

Manisha Shrestha
(074BAE218)

ABSTRACT:

Waste has been one of the major problems of the present world causing substantial environment impact and hazards in human health, worldwide. Rapid and haphazard urbanization along with unprecedented growth of urban population has directly served to generation of huge amount of unmanaged waste. The problem is severe in many developing nations and so is in Nepal. The most urbanized cities of Nepal, like Kathmandu lacks proper waste management infrastructures and facilities. While the generation of Municipal Solid Waste of Kathmandu Metropolitan City is about 600 tons/day, that is 50% of total waste of Kathmandu valley, there is no effective resource or infrastructures for recycling them. As a result, waste ends up in landfill sites, riverbanks and open spaces. Architects, however, are notably absent from the conceptualization, design and implementation of projects related to waste management facilities, which even worsens the case. This thesis tries to investigate the waste problem via the lens of design. This research aims to investigate and analyze present condition of municipal waste generation, composition and management in the Kathmandu valley. Also, it analyzes the changes and improvement needed on current MSWM system as it is ineffective and unsustainable. Thus, this thesis tries to interconnect the missing links between architecture and waste by design of a Waste Recycling Center for Kathmandu Metropolitan city. The thesis aims to generate a sustainable system of waste management within the design of public space, integrated in waste recycling facility that adds up value to architecture of such buildings otherwise considered dull and alienated. It will attempt to closely link public activities and the waste process through the integration of architecture and landscape in order to encourage public participation and break down the physical and mental 'border' between the public and waste. The main concept is to design waste recycling centers not only for their service function, but also for public spaces in the city. Hence, the main objective of this thesis project is to propose an innovative concept that connects urban waste infrastructure and public facilities via architecture and landscape to establish a new avenue for public participation with waste processes.

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Abbreviations:

ADB: Asian Development Bank
BIG: Bjarke Ingels Group
FAR: Floor Area Ratio
MSW: Municipal Solid Waste
KMC: Kathmandu Metropolitan City
ROW: Right of Way

1. INTRODUCTION

1.1 BACKGROUND

Waste is defined as unwanted or unusable materials or by-products of everyday item we consume, to sustain life. It is referred to any substance which is discarded after its primary use and is worthless and no more of use. Waste are of various types and can be classifies into various categories according to the source of production. It can be classified on the basis of its state, property, and its effect on the environment and health. Specifically, solid waste includes organic wastes, plastics, paper, metal, glass, etc.

Recycle means the process of collecting and processing materials that would otherwise be thrown and turning them into new useful products. Recycling process involves, collection, processing or manufacturing and storage of the product and its purchase. Thus, **waste recycle** simply means to process our wastes and produce usable products from the unwanted wastes. This is an excellent concept to consider and adopt because **"one man's trash is another man's treasure**." It not only decreases waste but also produces other useable resources that may be used for good purposes, thus reducing the negative effects of waste on the environment and health.

1.2 PROJECT INTRODUCTION

Waste recycling center is specialized area where waste is collected and recycled. This project **"Waste Recycling Centre" for Kathmandu Metropolitan City** aims to investigate the city's waste problem and offer a sustainable and environmentally friendly recycling practice through the design of a recycling center. The waste, in the project, only refers to **Municipal Solid Waste**, which comprises of everyday items that we use and eventually dump. It includes organic wastes, food, paper, plastics, metals, textiles and others.

Solid waste management (SWM) is a severe environmental problem in many developing countries, including Nepal and especially in cities like Kathmandu. Municipal waste is expanding on a daily basis as a result of population growth, rapid urbanization, and the availability of various physical facilities. The establishment of industries, the development of commerce, the adoption of new technologies, and changes in consumption habits have resulted in an increase in waste generation as well as a change in the nature and composition of solid waste in Kathmandu.

But still, Kathmandu lacks the practice of waste recycling as no proper waste management facility has been designed that is causing major environmental issues and unfavorable living conditions. Thus, the design of such waste recycling facility is seen as absolute necessity at present, to cope with the problems caused by lack of proper waste management system in Kathmandu.

Hence, the project - **Waste Recycling Center** will be a comprehensive facility dedicated to recycling **Kathmandu's municipal solid waste** while also offering a better working environment for staff and additional function and opportunities for public engagement.

1.3 NEED IDENTIFICATION/JUSTIFICATION

1.3.1 Rapid and Haphazard Urbanization and unprecedented population growth

Urbanization is inevitable for development and essential tool in making the lives of people better and qualitative. But, Nepal, especially Kathmandu Metropolitan City is facing the problem of **rapid and haphazard urbanization along with unprecedented growth of urban population.** Population growth, combined with fast urbanization, is one of the world's major concerns, resulting in increased solid waste creation per unit area. Urbanization and rapid financial growth of urban communities improve the socioeconomic status of the population, resulting in increased food consumption and, as a result, increased waste generation. (Raju Khadka, 2021)

Kathmandu Metropolitan City (KMC), the capital of Nepal, is the most urbanized and populous city in Nepal that houses approx.**1.45 million** population within an area of 50.67 km^2 at present. From1991 to 2001, KMC's urban population grew by 7.9% from, **427,045** to **671,805**. According to 2011 Census conducted by Central Bureau of Statistics (CBS), Kathmandu Metropolitan City had total population of **975,453** with an annual growth rate of 6.12%.(*How Kathmandu's Waste Management Emerged as a Perennial Problem*).

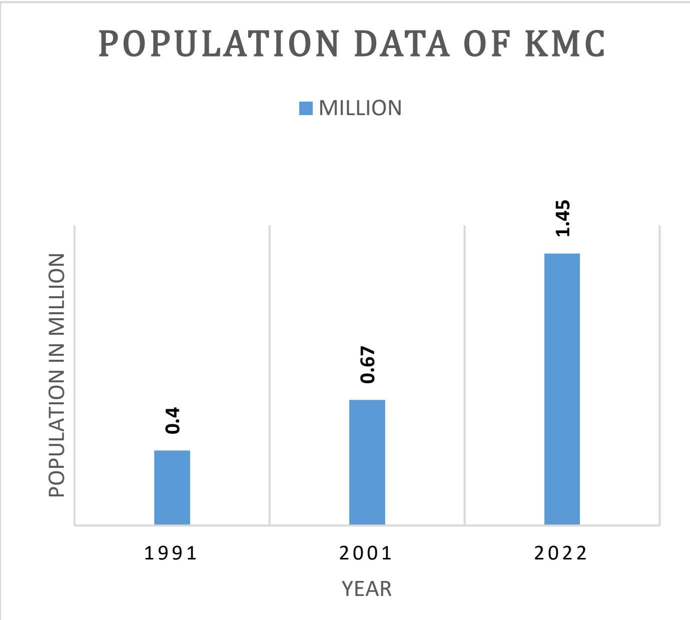


Figure 1: Population data of KMC
Source: (Raju Khadka, 2021)/CBS

From 2001 to 2011, population in KMC increased by 4.76% per year. During the same time period, waste generation increased by 5.36% per year. (Raju Khadka, 2021) The average household waste generation in KMC was around **375 ton/day** during late 2010. As per the report in 2013" **Solid Waste Management for Kathmandu Metropolitan City**" Kathmandu produces **479 tons** of solid was per day. **Environment Audit report, 2015**," Solid Waste Management of Kathmandu Metropolitan City "states as per data provided by the KMC the amount of daily waste generation is **524 tons** and out of which 16 tons of waste has collected. *(Solid Waste Management of Kathmandu Metropolitan City, 2015)*

At present, every day the Kathmandu Valley generates around 1200 metric tons of solid waste, of which 50% comes from the Kathmandu Metropolitan City alone that is equivalent to **600 metric tons**. (*How Kathmandu's Waste Management Emerged as a Perennial Problem*). Thus, increasing metropolitan solid waste and a lack of concrete information sources are growing concerns in developing-country cities such as Kathmandu Metropolitan City (KMC) in Nepal. (Raju Khadka, 2021)

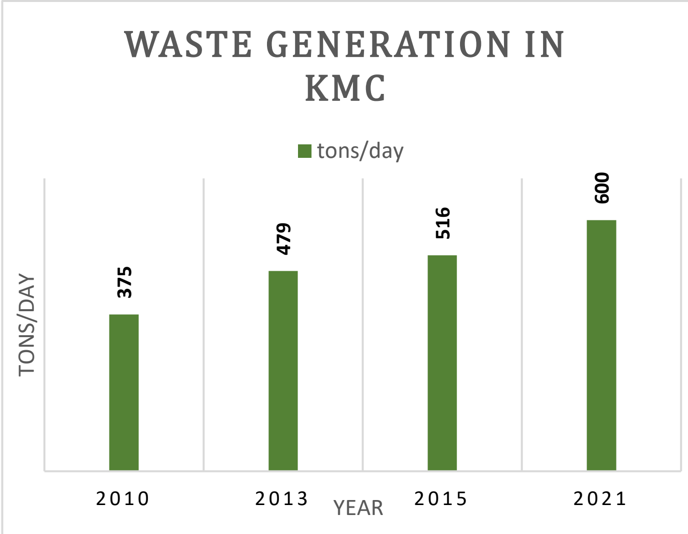


Figure 2: Waste generation of KMC
Source: (Asian Development Bank, 2013) (Solid Waste Management of Kathmandu Metropolitan City, 2015)

1.3.2 Recycling: the most ignored practice

While the generation of waste is increasing rapidly in one hand, on the other hand we lack efficient solutions to manage and recycle those waste. We lack the notion of recycling, as well as efficient waste management infrastructure and resources, where waste can be recycled. The inadequate practice of reuse topped by the insufficient establishment of **resource recovery center, most** of the waste are seen thrown in landfill sites, riverbanks and open spaces.

The waste composition of Municipal solid waste of Kathmandu consists of organic waste, plastic, paper and paper products, glass metal, textiles and others. It constitutes 51% organic and 49% recyclable comprising 5% paper and paper products, 3% glass, 1% metal, 19% plastic, 13% textiles, 4% rubber and leather and 4% other waste. (Raju Khadka, 2021). The waste composition analysis indicates that the highest waste fraction is organic matter, followed by plastic and paper.

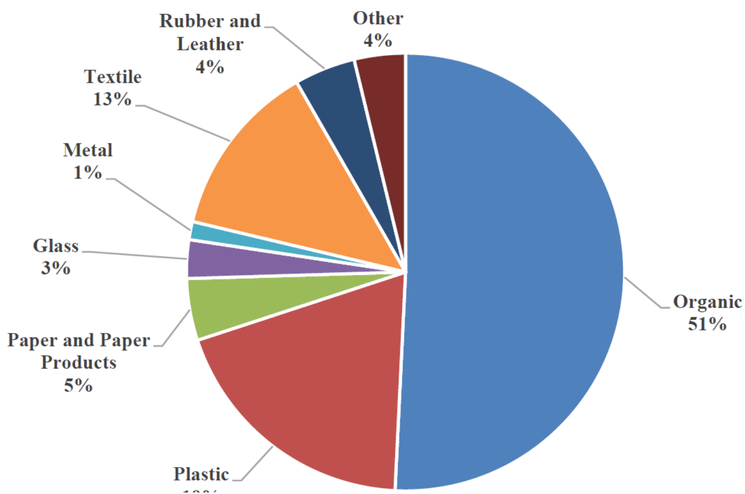


Figure 3: Waste composition of KMC
Source: (Raju Khadka, 2021)
Factors Influencing Municipal Solid Waste Generation and Composition in Kathmandu Metropolitan City, Nepal

Among them, the study shows **95%** of them has potential to be recycled. But recycling activities are very limited and informal.

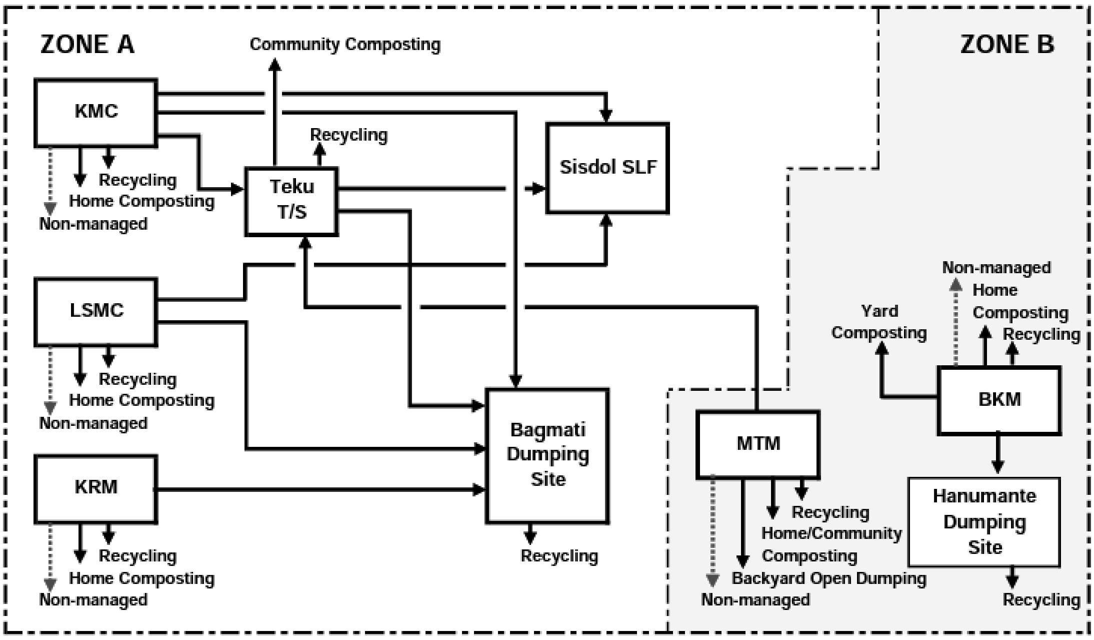


Figure 4: Waste flow diagram of Kathmandu valley

Source: (NIPPON,YACHIYO, September 2005)

Even though the process recycling is mentioned on waste flow chart, it is one of the most ignored practices which puts further stress on the landfill site. The practice of sanitary waste management at the household level also seems to be missing. Kathmandu Metropolitan City (KMC), the authority mandated for solid waste management (SWM) in Kathmandu, does not have any formal mechanism for recycling. *(Rana, 2013)*

So, if only recycling of municipal solid waste (from 95% of the waste that can be recycled) could be done with the provision of the proper infrastructure for waste management, it would reduce the practice of dumping waste all over the place and that would minimize the exports of waste to landfills, eventually minimizing the risks on environment and health. This makes the need of well-designed waste recycling center inevitable.

1.3.3 Lack of architecture in waste management

The waste management operation is not directly connected to architecture, as there is a missing link between architecture and waste that is neglecting the ability to design to positively impact the relation between people and waste. The waste management facility is generally perceived more as of mechanical and civil engineering but, the **infrastructure of waste management** is totally tied up with the ideas of **designing spaces that facilitates collection and recycling of the waste materials** to produce something reusable. Waste can be converted into **an opportunity** by incorporating its **function and value** into urban fabric **through architecture**. **Design of** waste **recycling centers** integrated with **public functions** can be new approach to define **architecture of waste**. Proper design approaches that addresses:

- Better planning
- Local environment
- Energy efficiency
- Material and technology
- Sustainability
- Public amenities is only provided through architecture.

A solid waste management facility is one of the infrastructures that serve to make a city a better place to live. Architecture is intimately linked with a city's infrastructures in order to provide a comfortable and suitable living environment for its users.

Thus, the design of waste recycling centers can be a prominent solution to the current scenario of waste mismanagement in Kathmandu, resulting in waste not remaining as waste but becoming an income-generating activity that is not only conceived as storage space but also characterized by functional and spatial quality with productive and generative spaces.

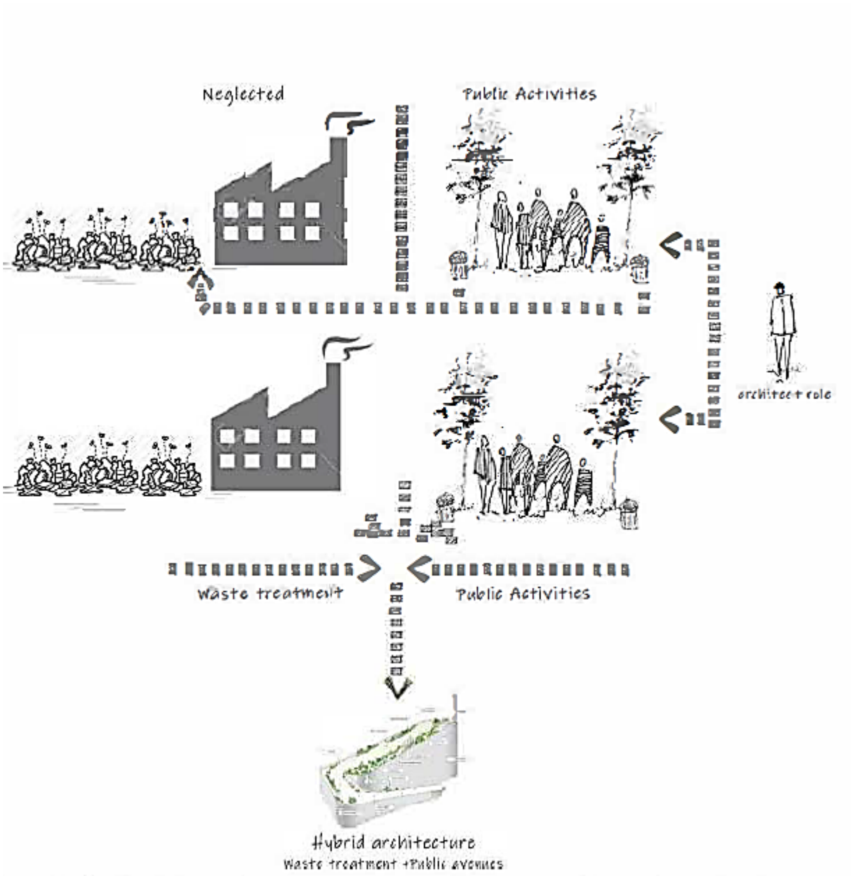


Figure 5: Link between Architecture and Waste
Source: (Bushra Subah, 2021)
Community Recycling Centre

1.4 IMPORTANCE

This thesis will be significant in the context of addressing the critical problem of waste management in Kathmandu Metropolitan City and providing an effective solution through architecture, as the design of a waste recycling center with integrated public facilities would be an innovative method for defining waste architecture in the Nepalese context. It would be beneficial to comprehend the significance of such facilities and their relevance to sustainable development. This thesis investigates how architecture may play a role in building a sustainable waste management system and connecting the public.

1.5 SCOPE AND LIMITATIONS:

This project deals with the present scenario of municipal solid waste, quantitative analysis of its generation, and design of Waste Recycling Center as a solution to solid waste management of Kathmandu valley. However, the research has its limitations which are listed as:

- The waste referred in this thesis project solely refers to only Municipal Solid Waste.
- The project concerns only with treatment plants within the built form but not the overall waste management system of collection, transfer, transport.
- The design does not include the technical processes of the equipment and machinery. As a result, only spatial requirements of machineries are taken into account.

1.6 OBJECTIVES

The major objective of this thesis project is to investigate and study the waste management problem of Kathmandu Metropolitan city and design a **waste recycling center** with recycling and recreational components to facilitate proper waste management. Specifically, the objectives are:

- To design a recycling facility not only as infrastructure, but as a place for public engagement by linking public activities with waste infrastructure through architecture and landscape.
- To generate sustainable system of waste management through design of waste recycling center with use of green building techniques.

1.7 METHODOLOGY

The research methodology for the very topic comprises of following:

- **Identification and statement of current problem**
- **Research**
  - Literature review
  - Case studies: national and international
- **Data collection and analysis**
- **Site selection**
  - Site analysis
- **Design**
  - Program formulation
  - Conceptualization
  - Zoning
  - Planning
  - Visualization
  - Evaluation of output
  - Preparation of architectural drawings3d models, reports

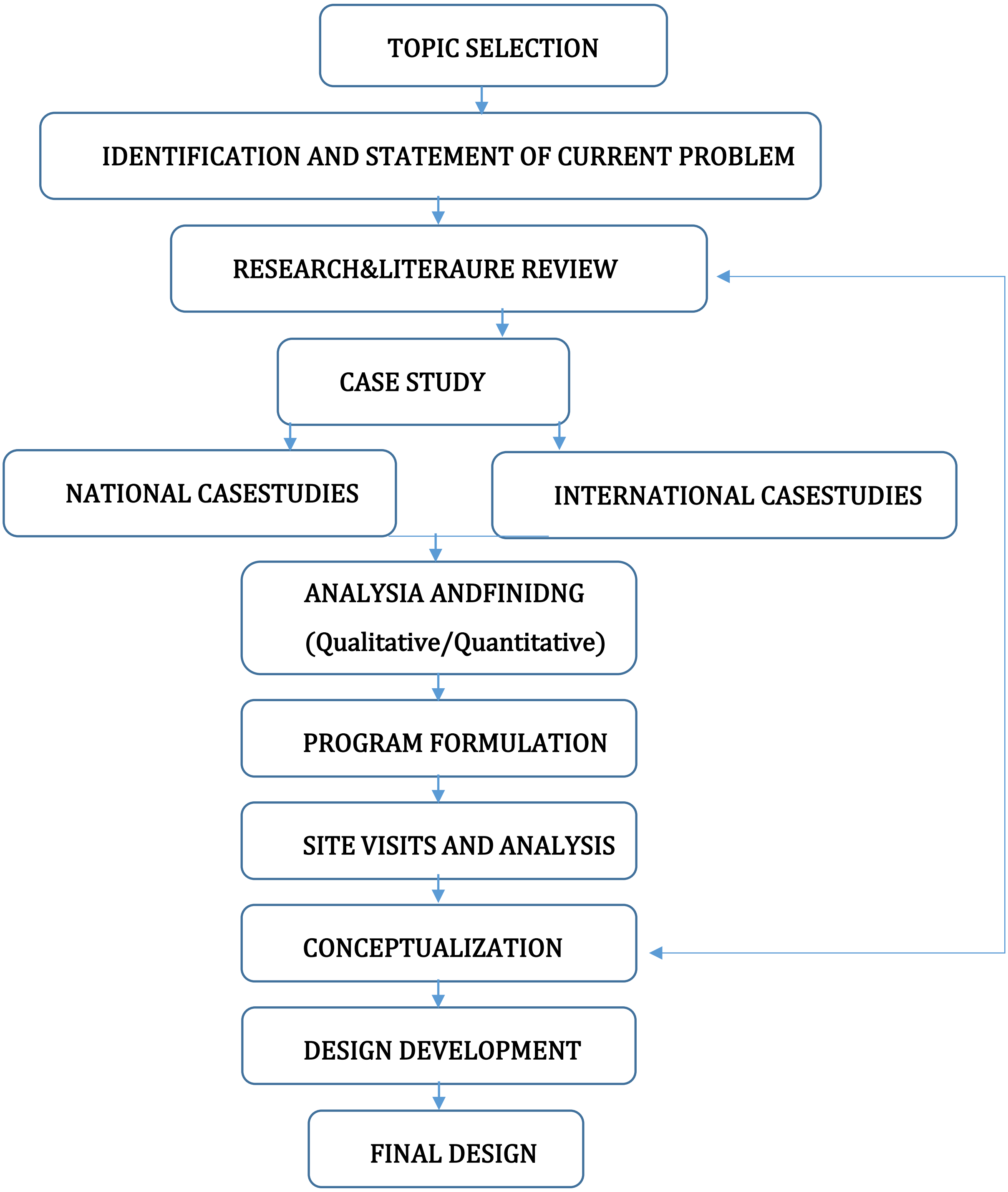


Figure 6: Methodology Flowchart

1.8 EXPECTED OUTPUT

The expected output of the thesis project are as discussed below:

- Design of **waste recycling center** not only as services but as facilities with new functions and avenues for public engagement.
- Sustainable waste management solution.
- Improvement of city environment.

2. LITERATURE REVIEW

2.1 WASTE

2.1.1 Introduction:

Waste is defined as the unwanted or unusable materials , that are no more of use. It is regarded to any substance that is discarded after its primary purpose or that is worthless, faulty, or useless. It is an unavoidable component of our daily lives as it is a byproduct of the everyday substances we consume to sustain life.

Figure 7: Waste condition in KMC

The definition of Waste has been generally tied to the concept of disposal.

Article 5 of the **Basel Convention**: "'Wastes' are substances or objects which are disposed of or are intended to be disposed of or are required to be disposed of by the provisions of national law".

Organization for economic co-operation and development (OECD): Wastes are substances or objects, other than radioactive materials covered by other international agreements, which: I) are disposed of or are being recovered; or ii) are intended to be disposed of or recovered; or iii) are required, by the provisions of national law, to be disposed of or recovered.

Waste Framework Directive of the European Union, Article 3: "'Waste' means any substance or object which the holder discards or intends or is required to discard." (*Definition and Classification of Waste*)

The term 'waste' has a different meaning for different people. In general, waste is 'unwanted' for the individual who discards it; a product or material that no longer has value for the first user and is thus discarded. However, the term "unwanted" is subjective, and the waste may have worth for another individual in a different situation, or even in a different society. Many large companies rely mostly or entirely on waste materials - paper and metals being the most frequent - as industrial feed stocks.

2.1.2 Classification of Waste:

i. Wastes can be classified under various categories based on their **physical state as:**

- Solid waste
- Liquid waste
- Gaseous waste

Figure 10: Solid Waste

Figure 9: Liquid Waste

Figure 8: Gaseous Waste

Solid waste:

United states Environment Protection Agency**,** EPA defines solid waste as any garbage or refuse, sludge from a wastewater treatment plant, water supply treatment plant, or air pollution control facility and other discarded material, including solid, liquid, semi-solid, or contained gaseous material resulting from industrial, commercial, mining, and agricultural operations, and from community activities. (*About Hazardous and Non-Hazardous Waste* |)**.**

ii. Classification of wastes according to their **properties:**

- Bio- degradable
- Non biodegradable

Figure 12: Biodegradable waste

Figure 11: Non-Bio-Degradable Waste

iii. Classification of wastes according to **their effect on environmnet and human health**:

- Hazardous
- Non- hazardous*(Bibhabasu Mohanty)*

Defining and classifying waste based on environmental and human health concerns is an essential factor for legislators and governments to address in order to ensure suitable and effective waste management. Wastes can be managed and disposed of more effectively if they are classified into groups that represent similar risks to the environment and human health. (*1.1. Definition and Classification of Waste*)

Hazardous waste:

According to the EPA the definition of "Hazardous waste is waste that is dangerous or potentially harmful to our health or the environment. Hazardous wastes can be liquids, solids, gases, or sludges. They can be discarded commercial products, like cleaning fluids or pesticides, or the by-products of manufacturing processes."

Hazardous waste is defined as waste that has been classified as potentially harmful to the environment or human health and hence that requires special, distinct treatment and handling. Chemical treatment, incineration or high-temperature treatment, safe storage, recovery, and recycling are among options for hazardous waste treatment. The majority of hazardous waste comes from industrial activities.

Non hazardous waste:

Non-hazardous/solid waste includes all waste that is not categorized as hazardous, such as paper, plastics, glass, metal and beverage cans, organic waste, and so on. While not hazardous, solid waste can have major environmental and health consequences if it is not collected and managed. It includes the waste that does not harm the environment or human health in a direct way but on the long term may it possible destroy the environment, such as paper, plastics, glass, metal and beverage cans, organic waste, and so on.

Municipal solid waste:

This thesis project is only concerned with municipal solid waste that is defibed as what we personally throw away and discard on a daily basis. MSW is generated mainly from residential and commercial sources. MSW is broadly classified as *biodegradable* (organic/wet waste): food waste, paper, plants; and *non-biodegradable* (inorganic or dry waste): human made materials—plastics, glass, metal—that do not degrade for long periods or even ever, unless incinerated.

The EPA officially defines it as: “Municipal Solid Waste (MSW)—more commonly known as trash or garbage—consists of everyday items we use and then throw away, such as product packaging, grass clippings, furniture, clothing, bottles, food scraps, newspapers, appliances, paint, and batteries. This comes from our homes, schools, hospitals, and businesses”. *(Municipal Solid Waste | Wastes | US EPA).* The EPA breaks MSW into nine sub-categories including, paper, glass, metals, plastics, rubber, leather and textiles, wood, yard trimmings, food, and other.

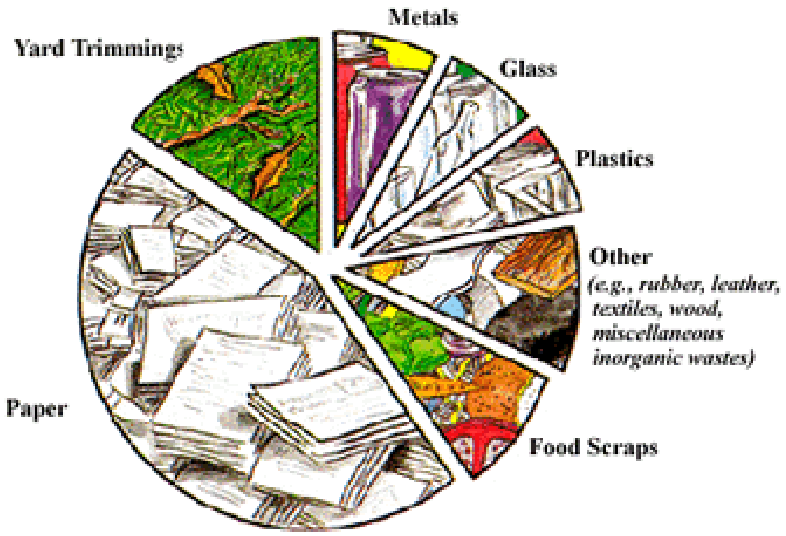


Figure 13: Composition of MSW

Source: (*Municipal Solid Waste*)

To sum up, the classification of waste can be studied as:

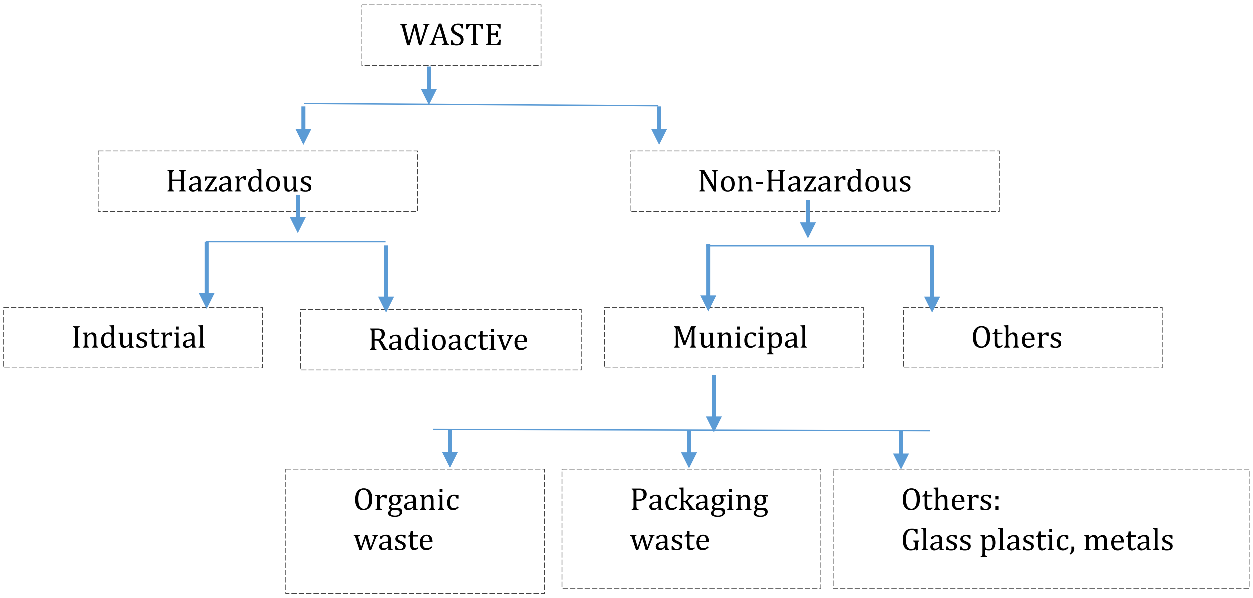


Figure 14: Classification of Waste

Source: (*1.1. Definition and Classification of Waste*)

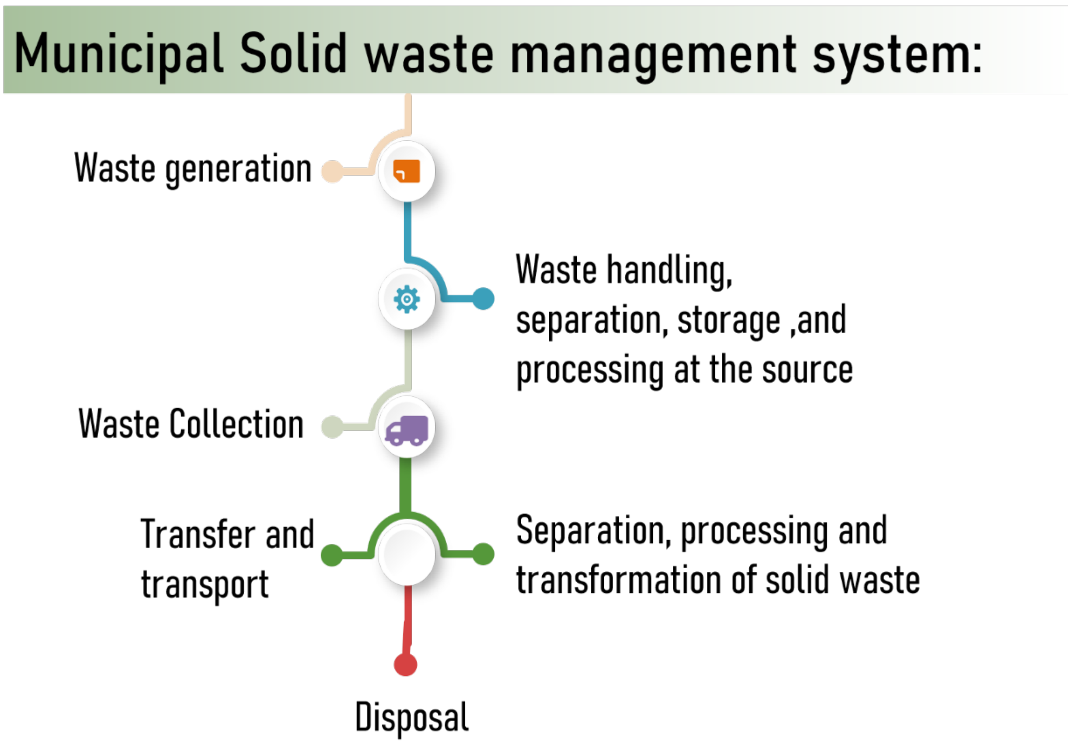
2.2 SOLID WASTE MANGEMENT SYSTEM:

According to Britannica," **Solid-waste management**, the collecting, treating, and disposing of solid material that is discarded because it has served its purpose or is no longer useful. Improper disposal of municipal solid waste can create unsanitary conditions, and these conditions in turn can lead to pollution of the environment"*(Solid-Waste Management | Definition, Methods, Importance, & Facts | Britannica)*. **Solid waste management** is defined as the discipline associated with the control of solid waste generation, storage, collection, transport or transfer, processing, and disposal in a manner that best addresses a range of public health, conservation, economic, aesthetic, engineering, and other environmental considerations.("An Introduction to Solid Waste Management").

Solid waste management is all about how solid waste can be changed to valuable resource. The major purpose of solid waste management is to reduce and eliminate the negative effects of waste products on human health and the environment in order to promote economic development and a high quality of life. This must be done in the most effective way feasible in order to keep expenses low and waste building to a minimum. *("An Introduction to Solid Waste Management")*

2.2.1 6 Functional Elements of the Waste Management System

There are six functional components of the waste management system, as outlined below:



Functional Elements of the Waste Management System:

1. **Waste generation**: This includes all operations associated with identifying materials that are no longer usable and are either gathered for systematic disposal or discarded.
2. **Onsite handling, storage, and processing**: This involves the activities associated with management of waste until they are placed in storage containers to the point of collection. This relates to activities at the point of waste generation, which facilitate easier collection. For example, waste bins are placed at sites that generate sufficient waste. Currently source separation of biodegradable ad non-biodegradable wastes at source is being obligation.
3. **Waste collection:** This is an important phase of waste management since it comprises tasks such as placing waste collection bins, collecting waste from those bins, and accumulating trash in the area where collection vehicles are emptied. This location maybe a materials processing facility, a transfer station or a landfill disposal site.
4. **Waste transfer and transport**: These are the activities involved in transporting waste in large waste transport vehicles from local waste collecting locations to regional waste disposal sites. This involves two steps:
    1. Transfer of waste from smaller collection vehicle to larger transport equipment
    2. Subsequent transport of waste, usually over long distances.
       The transfer usually take place at a transfer station.

5. **Waste processing and recovery**: This refers to the facilities, equipment, and techniques used to recover reusable or recyclable materials from waste streams and to improve the effectiveness of other waste management functional aspects.
6. **Disposal**: This is the final stage of waste management. It involves the activities aimed at the systematic disposal of waste materials in locations such as landfills or waste-to-energy facilities.

("Integrated Solid Waste Management (ISWM) - An Overview")

2.2.2 MSW management approaches:

There are number of concepts about waste management which vary in their usage. Some of the emerging concepts of Municipal solid waste management include:

2.2.2.1 Waste management hierarchy:

The waste management hierarchy is a widely accepted set of principles for managing waste efficiently and sustainably. The waste hierarchy is typically presented as an inverted pyramid that shows approaches to MSWM from most preferred to least preferred. The main aim of the waste hierarchy is to extract the maximum practical benefits from the products and to generate the minimum amount of waste.

Figure 15: Waste Management Hierarchy

2.2.2.2 Circular economy concept

The circular economy concept also emphasizes the first four steps of the waste management hierarchy but goes further in advocating for minimizing the quantity of waste that needs disposal**.** The circular economy is a proactive approach that advocates for designing products to reduce waste, using products and materials for as long as possible, and recycling end-of-life products back into the economy.

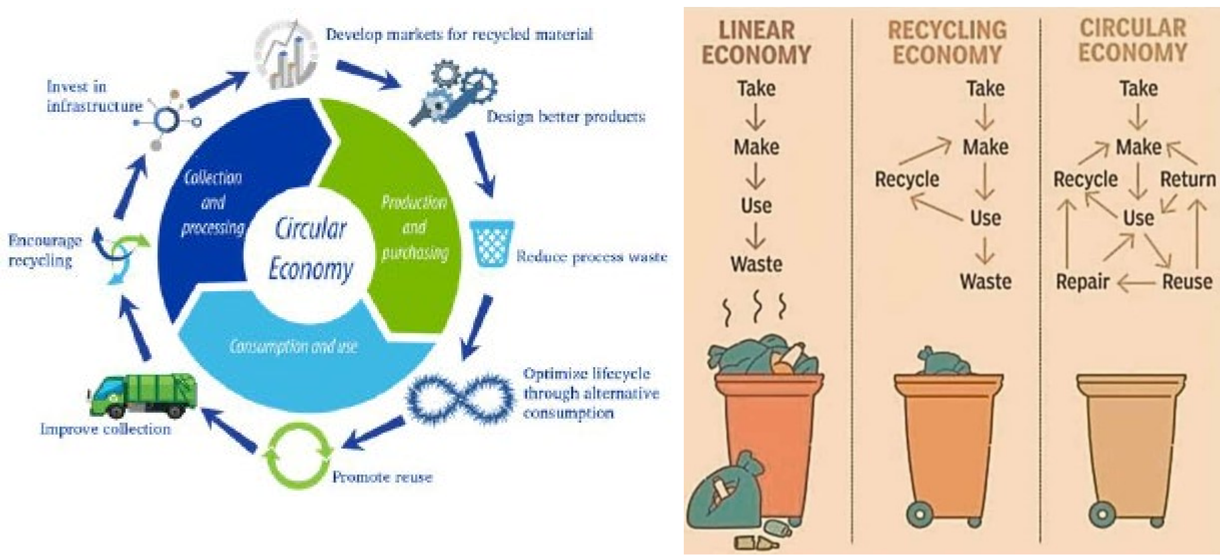


Figure 16: Concept of Circular Economy

2.2.2.3 Integrated sustainable waste management

Integrated Sustainable Waste Management (ISWM) represents a contemporary and systematic approach to solid waste management. The U.S. Environmental Protection Agency (EPA) defines ISWM as a complete waste reduction, collection, composting, recycling, and disposal system. An efficient ISWM system considers how to reduce, reuse, recycle, and manage waste to protect human health and the natural environment. It involves evaluating local conditions and needs. Then choosing, mixing and applying the most suitable solid waste management activities according to the condition.

("Integrated Solid Waste Management (ISWM) - An Overview")

The main concept of Integrated Sustainable Waste Management (ISWM) emerged from experience in order to address certain common issues with municipal waste management in low- and middle-income nations in the South. ISWM recognizes three major waste management dimensions:

- Stakeholders,
- Waste system elements, and
  Sustainability aspects (*Integrated Sustainable Waste Management (ISWM) | WastePortal*)

Figure 17: Integrated Solid Waste Management

2.3 OVERVIEW OF SOLID WASTE in the Kathmandu Metropolitan City

2.3.1 Description of study area:

The study area, Kathmandu Metropolitan City (85° 20’ East and 27° 42' north), lies in the Kathmandu Valley, Nepal. It covers an area of 50.67 km2. The elevation of Kathmandu is 1,350 meters above mean sea level. The Kathmandu Metropolitan City has a mild climate most of the year with summer temperatures ranging from 19-27°C and winter temperatures ranging from 2-20°C. Total annual rainfall in the area is 1,505mm. (Raju Khadka, 2021).

Kathmandu Metropolitan City (KMC), Nepal's capital, is the country's most urbanized and populated city. From 1991 to 2001, KMC’s urban population grew by 7.9% from, **427,045** to **671,805**. The population of the city has grown **975,453** as per 2011 Census conducted by Central Bureau of Statistics (CBS). At present, total population of Kathmandu Metropolitan City is approximately 1.45 million. (Raju Khadka, 2021)

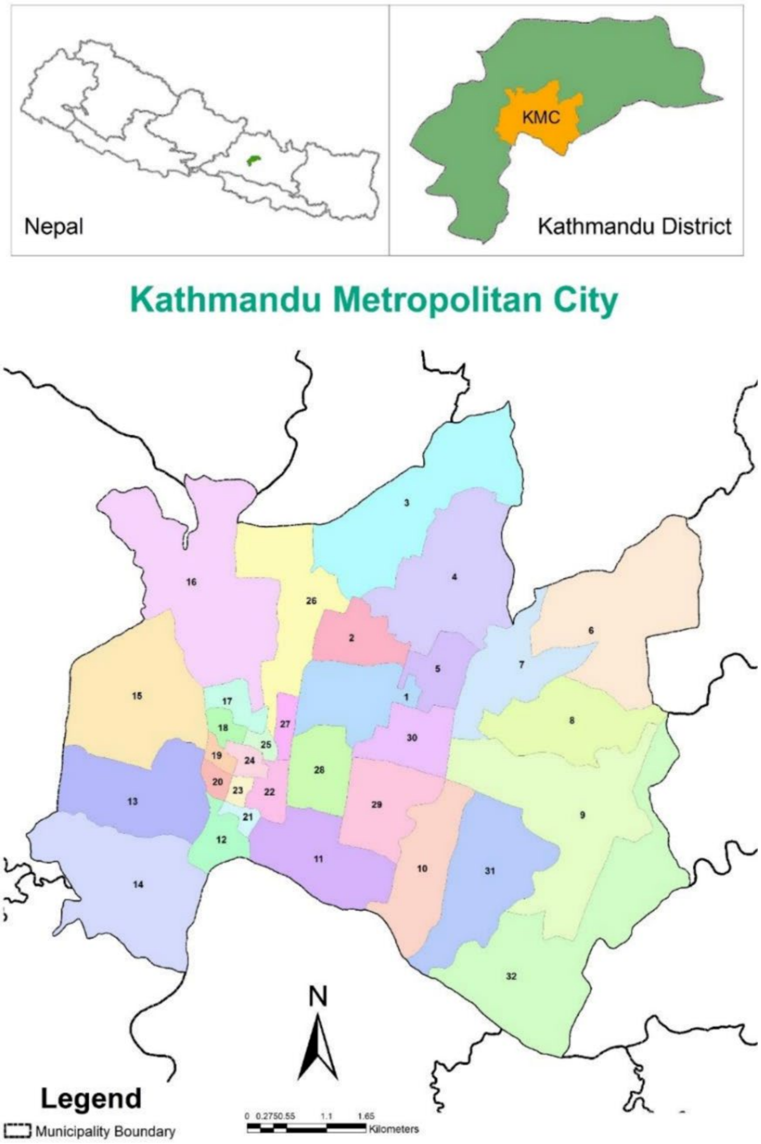


Figure 18: Study Area: Kathmandu Metropolitan City

There are 32 wards in KMC and the total number of households in KMC is 154,302. And, of them, the maximum population is in ward 16 with 84,441 people and 22,715 household as shown in figure 3. The minimum population is in ward 26 with 4,133 people and 947 households. The population density of KMC is 20,289 people per km^2 and the average household size is 3.94, which is below the national average of 4.21. Because of rapid population growth and urbanization, the quantity of waste generated in Kathmandu city is increasing rapidly so demanding attention for proper SWM. (Raju Khadka, 2021)

Over the previous two decades, the Kathmandu Metropolitan City has faced an increasing challenge. Population growth and rapid urbanization have increased the stress on the city's solid waste management system. One sanitary landfill site has already been exhausted, and solid waste is now being disposed of at a second sanitary landfill site. Recycling activities are minimal and informal, putting further strain on the dump site. The practice of sanitary waste management at the household level also seems to be missing. Thus, the Kathmandu Metropolitan City has significant challenges not just in terms of management, but also in terms of public knowledge and engagement.

2.3.2 History of Municipal solid waste management in KMC

Solid waste was not a major issue in the Kathmandu Metropolitan City in the old days. People in the Kathmandu had their own way of getting rid of household waste, which included a form of organic waste circulation between the city and neighboring rural areas. Historically and prior to urbanization of the Kathmandu, majority of the solid waste in Kathmandu consisted of organic waste. Households handled the garbage generated within the household. The majority of the garbage was composted at each household or repurposed and recycled inside each family.

In the 1960s, urbanization, as well as increased commerce and consumption, resulted in increased waste generation. As there was no formal waste management system in place people simply started dumping household waste along the Bagmati River. To solve this problem international aid agencies were consulted in 1971 for the first time and in 1981 GTZ’s solid waste management project started.

GTZ’s solid waste management project operated for approximately 10 years through the 1980s until the Government of Nepal assumed responsibility for managing the project. During the 1990s the waste management system in Kathmandu went into disrepair After the Gokarna landfill site was finally closed in 2000, waste began to be thrown haphazardly along riverbanks. Finally, in 2003, the Bagmati River's banks were formally used for solid waste disposal. In 2005, the development of the Sisdol landfill site halted dumping along the Bagmati. (Rana, 2013)

1. GTZ SOLID WASTE MANAGEMENT PROJECT (1981-1990)

The GTZ Solid Waste Management Project was established in 1981 with technical and financial support from the German Society for International Cooperation (GTZ). The project was implemented by the Ministry of Work and Transportation with cooperation with local municipalities.

The project's trial phase (1981-1983) investigated and developed innovative waste management ideas in Kathmandu. More waste was gathered as new brooms and push-carts were developed and implemented. However, waste continued to be deposited along the Bagmati River.

During the project's Acting phase (1983/84-1990), a comprehensive waste management strategy was adopted. To alleviate the environmental pressures of waste dumping on riverbanks the Gokarna landfill site was constructed and began operation in 1986. The Teku Transfer Station and composting plant also opened in the same year. Communal waste collection containers and new more efficient vehicles were introduced. The Solid Waste Management and Resource Mobilization Center (SWM&RMC) was established to handle waste management efforts. The project was transferred to the Ministry of Housing and Physical Planning near the end of the Acting phase (MoH&PP). GTZ reduced its technical and financial assistance to the project during the last phase of the project (1990). The SWM&RMC was given the responsibility of administering the Gokarna dump site. (Rana, 2013)

2. 1990-2000

After 1990, SWM&RMC took over management of the Gokarna landfill site. With rising urbanization and rapid population growth in the Kathmandu valley, the volume of solid waste generated has increased, putting additional strain on the waste management system. Furthermore, neglect and a lack of maintenance worsened the system. (Rana, 2013)

When the Teku composting factory closed in 1992, more waste was sent to the Gokarna landfill for final disposal. Inadequate infrastructure intensified the problems at the Gokarna landfill site. Inadequate site preparation and waste that was not properly covered resulted in waste being scattered in surrounding areas. Protests led by villagers resulted in the closure of the Gokarna dump site, although it reopened after a few weeks in 1993. (Rana, 2013)

Locals continued to protest, and the Gokarna dump site was closed again in 1994, not reopening until 1995. When the Gokarna landfill site closed in 1994-1995, waste began to be dumped along the Bishnumati River. The Gokarna dump site reopened in 1995, following the government's commitment to manage the site in an environmentally appropriate manner. (Rana, 2013). However, after closure of Gokarna LF in 2000 due to the opposition of the surrounding local people, final disposal could not help going to river side dumping on a temporary basis, e.g., Bagmati River dumping. BKM and MTM and have also been dumping their waste into the rivers nearby. (NIPPON,YACHIYO, September 2005)

3. 2000- now

Waste management for Kathmandu is the responsibility of KMC. The Environment Management Division of KMC manages waste collection and disposal. The majority of household waste is dumped on the streets or in public waste containers. Some waste is collected through going door to door. Individual waste collectors ride modified cycle-carts to collect waste, which is then put onto trucks or tractors. The gathered waste is first transported to the Teku Transfer Station, where it is separated, loaded onto larger vehicles, and transported to the Sisdol landfill site.

The Sisdol landfill site is now the only place where Kathmandu Valley's solid waste may be disposed of. It commenced operations in 2005. The landfill site is managed by the Solid Waste Management Technical Support Center (SWMTSC). SWMTSC is a self-governing entity within the Ministry of Federal and Local Development (MoFALD).

In Kathmandu, there is no organized recycling infrastructure. Some waste is sorted at the household level, and a few non-governmental organizations participate in recycling. A considerable part of waste, however, is sorted by "scavengers," or urban poor, on the streets or at the Teku Transfer Station. The materials sorted and collected by the scavengers, including as plastics, paper, glass, and metals, are sold to private enterprises, who primarily sell them in India.

Figure 21: Waste condition in KMC

Figure 20: Teku Transfer Station

Figure 19: Sisdole Landfill Site

2.3.3 Municipal Solid Waste generation situation in KMC

Solid waste management is one of Nepal's major challenges for municipalities, including those in the Kathmandu Valley, due to haphazard urbanization, a rapidly growing population, a lack of basic facilities for integrated solid waste management, and a deeply embedded misperception about waste management.

From 2001 to 2011, population in KMC increased by 4.76% per year. During the same time period, waste generation increased by 5.36% per year. (Raju Khadka, 2021) The average municipal waste generation in KMC was around **375 ton/day** during late 2010. As per the report in 2013" **Solid Waste Management for Kathmandu Metropolitan City**" Kathmandu produces **479 tons** of solid was per day. **Environment Audit report, 2015**," Solid Waste Management of Kathmandu Metropolitan City "states as per data provided by the KMC the amount of daily waste generation is **524 tons** and out of which 516 tons of waste has collected. (Solid Waste Management of Kathmandu Metropolitan City, 2015).

At present, every day the Kathmandu Valley generates around 1200 metric tons of solid waste, of which 50% comes from the Kathmandu Metropolitan City alone that is equivalent to **600 metric tons**. (*How Kathmandu's Waste Management emerged as a Perennial Problem*). Thus, increasing metropolitan solid waste and a lack of concrete information sources are growing concerns in developing-country cities such as Kathmandu Metropolitan City (KMC) in Nepal. (Raju Khadka, 2021)

The total amount of waste generated in a city, as well as its characteristics (composition), are critical considerations in solid waste management (SWM) system planning. The rate and composition of waste generation vary with population growth, lifestyle, economic activity, and seasonal events. The establishment of organizations and industries, the development and expansion of trade and commerce, the adoption of new technologies, and changes in consumption habits have resulted in an increase in waste generation as well as a change in the nature and composition of solid waste in Kathmandu (KMC).

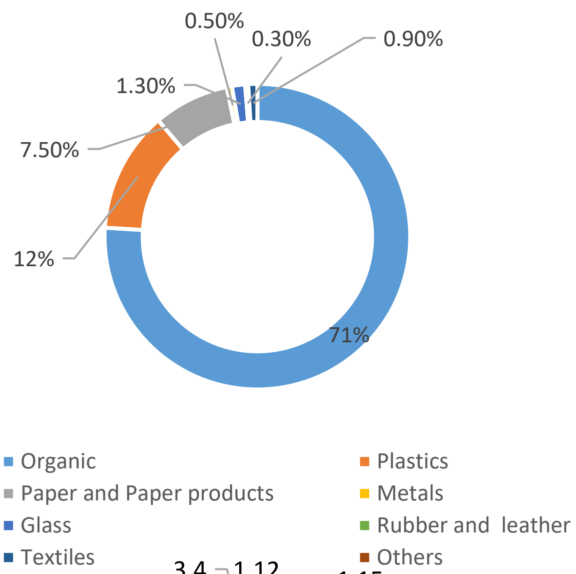


Figure 23: Waste composition of KMC as per ADB report, 2013

Source: (Asian Development Bank, 2013)

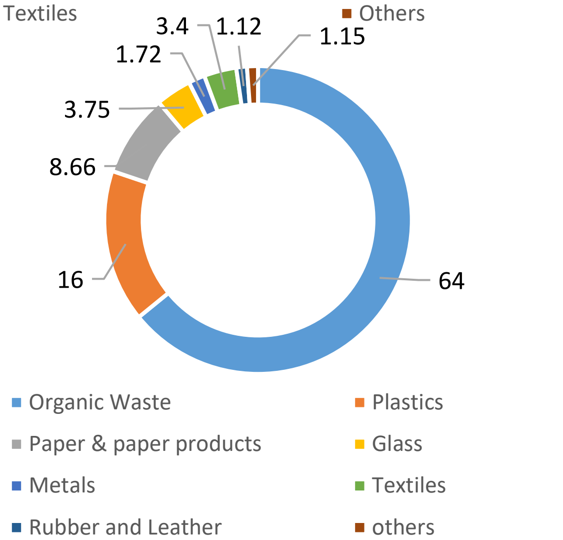


Figure 22: Waste composition of KMC as per Report in 2015

Source: (Solid Waste Management of Kathmandu Metropolitan City, 2015)

The waste composition of Municipal solid waste of Kathmandu constitutes 51% organic and 49% recyclable comprising 5% paper and paper products, 3% glass, 1% metal, 19% plastic, 13% textiles, 4% rubber and leather and 4% other waste. (Raju Khadka, 2021). The waste composition analysis indicates that the highest waste fraction is organic matter, followed by plastic and paper.

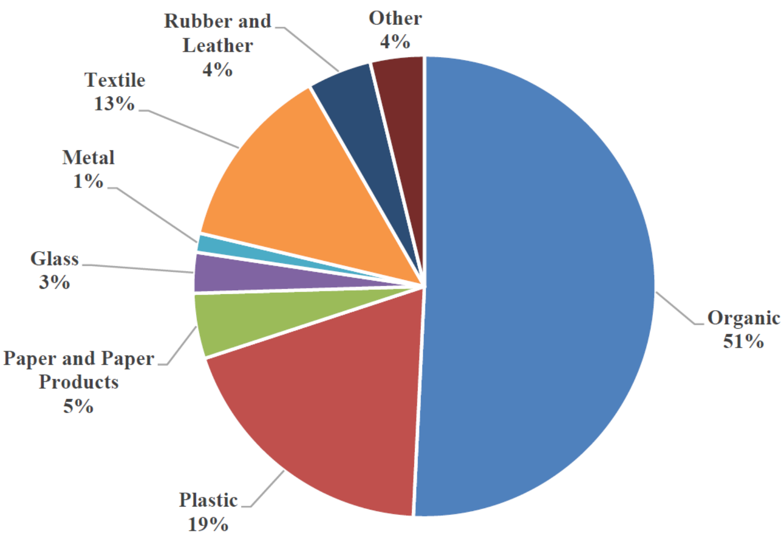


Figure 24: Waste composition of KMC as per data of 2021
Source: (Raju Khadka, 2021)

Among them, the study shows **95%** of them has potential to be recycled. But recycling activities are very limited and informal. The recycling practice is only limited to waste flow diagram but not in practicality.

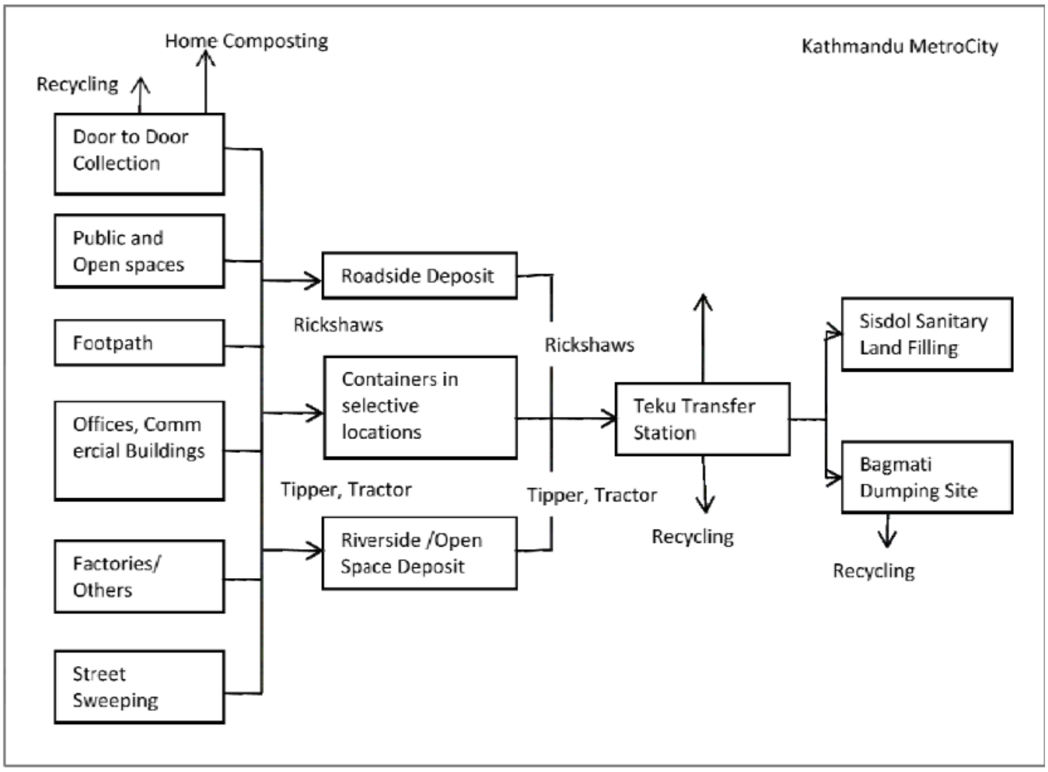


Figure 25: Municipal Solid Waste Flow Diagram of KMC
Source: (Gautam, 2011)

Solid waste management (SWM) services of KMC have consistently failed to keep up with the vast amount of solid waste produced in urban areas. There is no current efficient system in place for the management, storage, collection, and transport of solid waste. (Raju Khadka, 2021). Despite the fact that the Kathmandu Metropolitan City has a relatively high solid waste collection ratio when compared to other cities in Nepal, 17 municipalities, including two metropolitan cities, dump their solid wastes at the Sisdole dumpsite, which has already become a highly vulnerable .As a result, due to a lack of infrastructure for solid waste treatment and recovery, Solid Waste Management (SWM) poses a significant danger to the livability of the Kathmandu Metropolitan City and contributes to pollution and public health hazards at the final disposal location, namely the Sisdole dump site.

2.3.4 Key issues and problems

Though there have been substantial changes in people's perceptions about sanitation and solid waste management over the last 30 years, the general attitude of Nepali society has yet to shift. Everyone understands the difficulties and opportunities presented by solid waste, but no one wants to translate their understanding into behavior and action. Many people believe that waste should be thrown anywhere but not 'in my backyard.'

Similarly, the metropolis describes solid waste as a major problem. However, managing solid waste has been accorded a low priority mainly because the demand is higher for other public services in many municipalities in Nepal. Waste management involves more than just crisis management associated to waste collection and disposal, which simply transfers problems from one location to another. Municipalities and a few so-called experts believe that if waste segregation is done at the source, a large amount of biodegradable waste, or more than 60% of total waste, can be controlled at the source. However, this is not the case with poorly urbanized places such as Kathmandu Valley, where many people live in a single house with minimal open space and the city generates a massive amount of waste.

If the municipalities makes major efforts in soft intervention, around 5% of families will be able to manage their organic waste at the source. Other organic wastes, on the other hand, must be appropriately collected, transported, and treated. Not only does mandatory segregation help to solve current solid waste management problems, but it also requires that all operational components of the integrated SWM system, including separate collection and transportation of source-segregated waste, be followed, and if the collected waste is treated properly to recover as many resources as possible, only a limited amount of waste will go to the landfill site. The waste collector might create a waste collection schedule for this purpose. They can only collect biodegradable waste one day and non-biodegradable waste the next. It will aid in the maintenance of a proper waste segregation system; otherwise, this will be only a publicity effort. There are currently no systematic municipal waste recovery and recycling programs.

However, informal recycling activities occur among low-income people in Kathmandu Valley, where more than half of dry recyclable materials are gathered by these informal waste pickers and sold to local scrap shops for revenue production and livelihood. Yet, organic waste recycling is almost non-existent in the Valley due to a lack of infrastructure for organic recycling and recovery, which has resulted in major environmental problems at the disposal site.

Prior to the promulgation of the new constitution, a central government organization - the Solid Waste Management Technical Support Center (SWMTSC) - existed to provide technical support for technical, capacity building, policy, and plans related to SWM in municipalities, despite the fact that SWM operation was the primary responsibility of municipalities. At the federal and provincial levels, there is currently no specific unit to provide technical help to local governments in all aspects of SWM. (Pathak)

Since 2011, Nepal has used the concept of trash as a resource, with legal provisions requiring waste sorting at the source. As a result, waste management policies are turning away from waste disposal and toward recycling and recovery, and people are looking at waste as a potential new resource. However, this does not imply that there is no waste to be disposed of, that no space is necessary for waste management, and that everything can be managed at the source. (Pathak).

2.3.5 Solid Waste Management Policy and Legislation

Among the acts and policies pertaining to SWM, the **2011 Solid Waste Management Act** and **the 1996 National Policy on SWM** are particularly relevant. (Asian Development Bank, 2013)

The 1996 National Policy on SWM:

The National Policy on SWM was formulated in 1996 to address the emerging SWM problems due to urbanization. The policy emphasizes waste management in municipal and urban areas and is still in force. Its main objectives are to:

i. make SWM simple and effective,
ii. minimize the impact of solid waste on the environment and public health,
iii. treat solid waste as a resource,
iv. include private sector participation, and
v. Improve public participation by increasing public awareness about sanitation. (Asian Development Bank, 2013)

The Solid Waste Management Act 2011:

Chapter 2 of the Solid Waste Management Act 2012 imposes responsibility on the Local Body to make arrangement to manage solid waste and for management of solid waste activities. This includes recycling activities for which the Local Body can consult and coordinate with relevant industry. (Rana, 2013)

Chapter 4 of the Act permits private sector participation in solid waste management. The permission to participate must be granted through a license by the relevant Local Body and must be awarded through a competitive tendering under open tender.
(Rana, 2013).

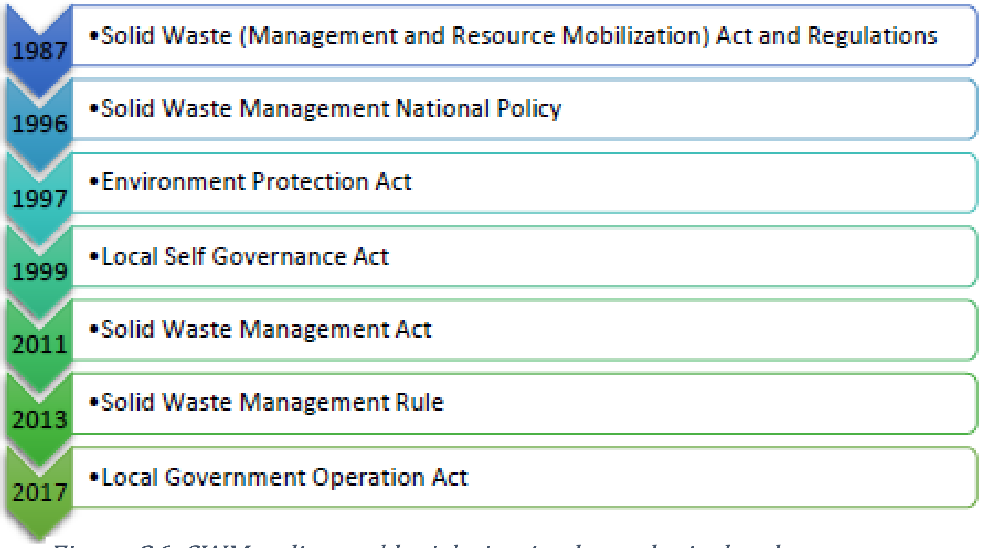


Figure 26: SWM policy and legislation in chronological order

2.4 ARCHITECTURE AND WASTE

Despite the considerable benefits that architectural engagement could provide, waste facilities and other industrial buildings are frequently deemed utilitarian and unattractive*("Architecture and Waste").* The waste management facilities are considered more as part of civil and mechanical engineering, but the notion that architecture can add value in design of waste management centers is evident. The infrastructure of waste management is inextricably linked with the ideas of building places that support waste collection and recycling in order to make something reusable. By incorporating waste's function and value into urban fabric through design, waste can be transformed into an opportunity.

Although waste management is not often associated with design, such as architecture and landscape, it does shape the places we live. Though waste management infrastructure is closely linked to city planning, but it is supposed to be an infrastructure, that is not visible to the public. As cities are growing in size and population, the issue of waste and energy are becoming more critical in terms of developing new innovative and sustainable waste management and waste reduction solutions providing proper waste managing facilities. To define the role of architecture and design discipline is one of the critical components in finding solutions to enhance waste management and improve the relation between the city and the city's main infrastructure. (Nobile, 2018)

2.4.1 Lack of Architecture in Waste Management:

With a few exceptions, architects are mostly absent from the conceptualization, design, and implementation of solid waste management projects. There is currently a missing link between architecture and waste that overlooks design's ability to favorably impact people's relationships with waste. Architects and designers currently have a limited role in the design and construction of industrial building types. Except for a few exemplary initiatives, architecture and design have been largely excluded from the development of these pervasive structures and their integration into larger built and natural environments. The built environment that houses waste management processes is usually hidden from public view. Because of this, as well as a lack of environmental and economic reasons, it is difficult for the general public to understand and adopt technological developments for solid waste management activities. (Nobile, 2018)

Architects may add value to industrial environments and promote healthier communities by participating in discussions regarding waste management and waste-to-energy potentials. New design concepts can offer hybrid solutions to create renewable energy, contribute to cities' social and cultural activities, and protect larger metropolitan atmospheres and microclimates inside this potential area. Today, as population density and consumption patterns in cities expand, we are at a crucial moment in establishing best practices for waste management techniques. With technological advancements, it is time to put in place sustainable infrastructure to accommodate current consumption trends, which is only possible through architecture (Nobile, 2018). It is because architecture only makes consideration for aspects such as:

- Better Planning
- High Efficiency
- Local environment
- Energy efficiency
- Material and technology
- Sustainability
- Public amenities

Taking these factors into account can only add value to waste management facilities, which are otherwise regarded as an unsightly and unwelcoming functional space. Thus, this thesis intends to engage in a discussion between architecture, waste management, and public engagement by studying the problem of waste management inside the city.

2.4.2 Architecture as Device: The design of Waste recycling centers:

The relationship between usefulness and quality is represented clearly through architecture. Architecture becomes a tool for interacting with individuals for 'educative' reasons, teaching them how to treat 'waste”. Hence, Architecture can be a device for designing of Waste recycling centers that are usually characterized as ugly and unwelcoming and conceived as disconnected from public, being only functional places.

Harvard University research entitled ‘Architecture and Waste’ highlighted several examples and case studies of waste-to-energy plants and waste management facilities that integrate public functions to engage communities beyond their core function. This study highlighted how architecture may contribute in the establishment of new opportunities. Recent hybrid architectural efforts have integrated recreational activities into previously abandoned and completely restricted public spaces. (Nobile, 2018)

Figure 28: Copen hill Waste-to-energy plants

Figure 27: Educational Centre in Brooklyn Recycling Facilities

The sky slope of the waste incinerator in Copenhagen, designed by BIG, and the educational centers in Brooklyn recycling facilities are just a few examples of architecture's contribution to the design of these infrastructures: 'These facilities illustrate how architects can add value to otherwise ordinary and alienating industrial spaces by infusing a sense of community and purpose. In addition to their aesthetic qualities, these buildings fulfill established environmental performance standards. (Nobile, 2018)

Thus, Waste management spaces and facilities, which began as plain technical rooms, are progressively undergoing architectural and aesthetic alterations and transformations. As a result of this transformation, they will serve as place for meeting, exchange, and access to knowledge, as well as places where new forms of experience are formed, good civic behaviors are involved, and, finally, new types of economy can emerge. In this regard, these facilities should also be characterized by functional hybridization and spatial quality, be aesthetically recognizable, and be conceived as productive and generative places, such as laboratories or factories, where research and innovation can drive a continuous transformation of matter and data, as well as an avenue for public engagement. (Nobile, 2018)

2.5 RECYCLING:

The common concept among all solid waste management techniques is recycling. Recycling is the concept that contradicts the definition of waste as no useful materials as it uses them as raw materials to produce some better output out of them. Recycling of waste can be defined as any recovery operation by which waste materials are reprocessed into products, materials or substances whether for the original or other purposes.(*Glossary*)

Recycling is the process of collecting and processing materials that would otherwise be thrown away as trash and turning them into new products. It is the reuse of resources and materials, and therefore their return to circulation. Recycling can benefit your community and the environment. Recycling is the process of treating waste as a raw material and converting it into a valuable product for consumption. It therefore sends materials around a continuous cycle of consumption, processing and treatment.

The basic phases in recycling are the collection of waste materials, their processing or manufacture into new products, and the purchase of those products, which may then themselves be recycled. Waste recycling involves the collection of waste materials and the separation and clean-up of those materials. Recycling waste means that fewer new products and consumables need to be produced, saving raw materials and reducing energy consumption. Recycling can be split into the subcategories 'Material recycling' and the organic recycling 'Recycling - composting and digestion'. The latter is only possible for separately collected organic waste.

The consumers buy products from the market and convert them into waste. The waste is then converted into raw materials by the processors and this raw material is converted back into products and supplied to the consumers by producers. Almost all waste can be a resource if its value is recognized and it can be utilized for productive purposes. In most cities, there are waste buyers who collect inorganic waste such as plastics, metal, paper and glass for recycling. Many of them go door-to-door looking for these valuable materials that can be sorted out of the waste stream. These materials are sorted, cleaned and packed and in this process, it is converted from waste to a raw material. This is then sold to waste dealers who then sell it to industries. The industries process the materials to produce new products. Organic waste however, is often not recycling organic waste usually results in relatively low value products.

2.5.1 Benefits of Recycling

Recycling has many benefits as listed:

- Reduces the amount of waste sent to landfills and incinerators
- Conserves natural resources such as timber, water and minerals
- Increases economic security by tapping a domestic source of materials
- Prevents pollution by reducing the need to collect new raw materials
- Saves energy
- Supports American manufacturing and conserves valuable resources
- Helps create jobs in the recycling and manufacturing industries. (*Sapkota,2022*)

2.5.2 Types of recycling:

All recyclables will fall into 3 main types of recycling: Primary, Secondary and Tertiary.

- **Primary Recycling**

Primary recycling occurs when a recyclable material or product may be recovered or reused in its original state. Many primary recyclables will be recycled for the same function for which they were developed. Primary recyclables should not be changed in any way. These recyclables may be thought of as secondhand. They may be utilized by you, donated or sold*(“What Are The 3 Types Of Recycling?”, 2020).*

Here are some primary recycling examples*:*

- Glassware – dishes, glass jars, etc.
- Toys- donate to charities, friends or family
- Electronics: Reuse in another area, sell or donate

- **Secondary Recycling**

Secondary recycling will be reused without the need for reprocessing. As a result, the material may be reused in a different way than it originally intended. This is common with DIY projects and can make a significant impact in keeping recyclable materials out of landfills. Here are some secondary recycling examples:

- Use of half of a plastic bottle to use it as a plant pot.
- Reuse of plastic, paper, wood, metals to do any type of DIY project.

- **Tertiary Recycling**

Tertiary recycling involves chemically changing items or materials to make them reusable. This can be done either internally or externally. External recyclables are recovered and treated at a public facility. It would entail sorting recyclables and placing them in containers to be delivered by a reprocessing factory. Internal recycling is where no public service is engaged. Some factories or manufacturers may engage in internal tertiary recycling.*(“What Are The 3 Types Of Recycling?”, 2020)*

2.6 WASTE RECYCLING CENTER:

Recycling centers, as the name implies, are specialized areas where waste is collected and recycled**. Waste Recycling center** refers to a facility that processes and converts waste into reusable material. Recycling centers are specialist locations where rubbish is taken to be recycled. It is defined as a facility that collects valuable materials from a waste stream or transforms or remanufactures the material into a usable form having established or potential market value.

Recycling facilities ensure that all material that can be reused are recycled. Hence sending, waste to a center means fewer items are sent to landfill sits and therefore the impact on the environment and human health is reduced.

Typically, the character of such waste recycling facilities is conceived unappealing and unwelcoming. They are regarded of as disconnected from the public, both socially and visually, because they are only functional areas, such as factories. So, design of a waste recycling center that integrates public functions to engage communities beyond their core function can add value to otherwise dull and alienated industrial environments, infusing them with a sense of community and purpose.

Thus, a design of waste recycling center need to integrates three major components:

- Facilities relating to waste recycling
- Better working environment to employees
- Amenities for public engagement

Beyond their aesthetic qualities and functional requirement, these buildings need to meet established standards of environmental performance and need to adopt green building techniques to achieve sustainability.

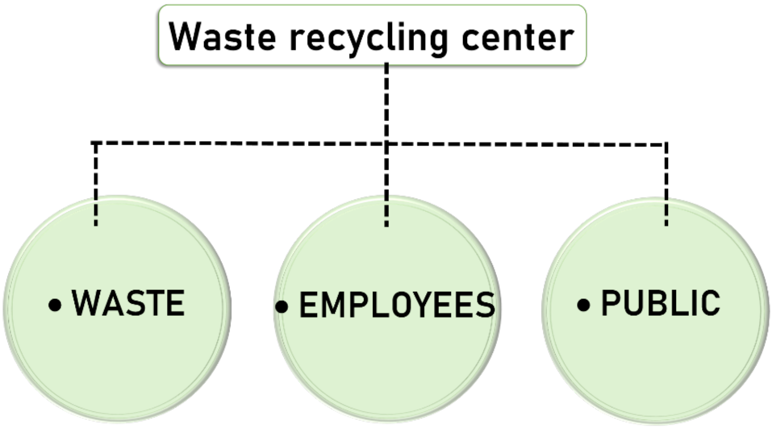


Figure 29: Components of Waste Recycling Centers

2.6.1 **Waste facilities**:

Waste is the major component to deal with in any waste recycling center. The basic flow of waste involves:

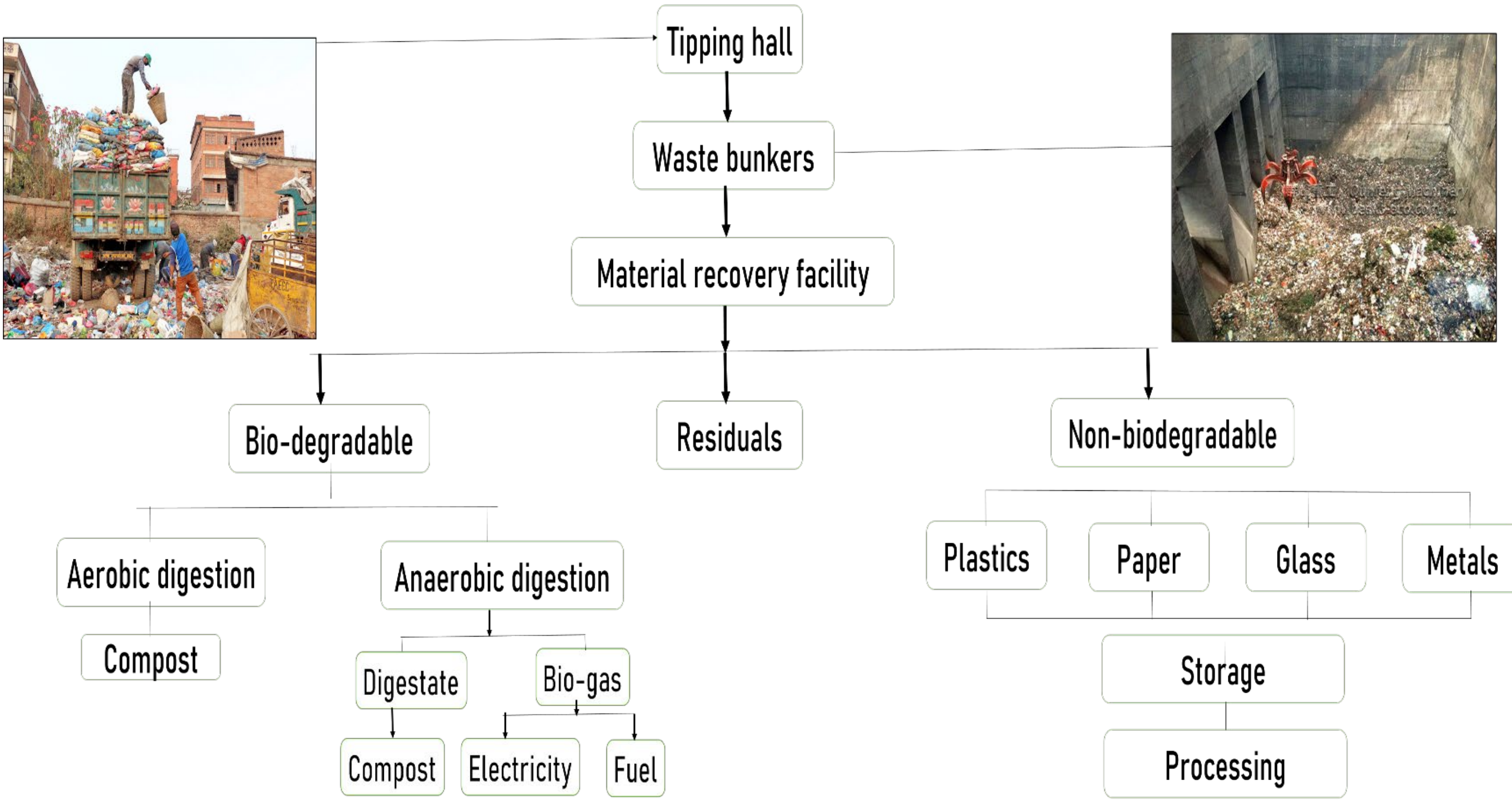


Figure 30: Flow Chart of functions for Waste

2.6.1.1 Tipping hall

In the tipping hall the waste is tipped into one of several tipping bays. Each bay has a hydraulically operated door designed to minimize noise and odor during tipping. Lights on each tipping bay indicate to the drivers of the vehicles which bay is available to receive waste.

Figure 31: Tipping Hall

Source: Riverside Resource Recovery Energy from Waste Facility

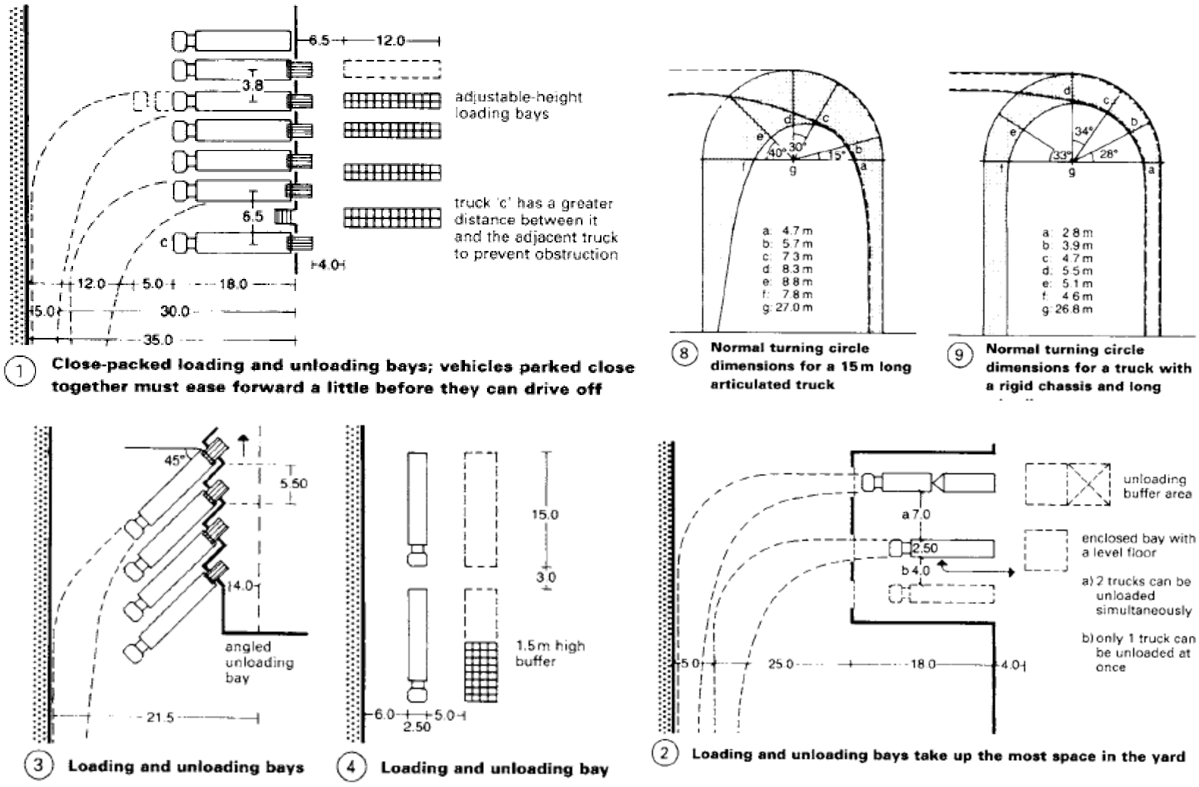


Figure 32: Tipping Bays standards

Source: (Neufert Architect's Data)

2.6.1.2 The waste bunker:

The tipping bays open into a waste bunker which is very deep. Waste is collected and stored in waste bunkers. The waste storage bunker in the reception hall is an important part of the waste recycling plant. Its purpose is to provide a place to store, buffer and uniformly mix the delivered waste and ensure a continuous supply of waste to the material recovery facility.*(KG)*

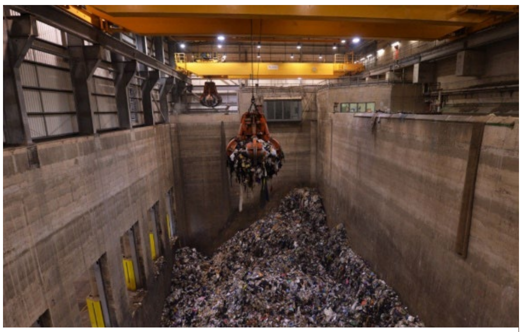


Figure 33: Waste storage Bunker

Source:(*FCC Lincolnshire EfW What Is an EfW?*)

2.6.1.3 MRF-Material Recovery facility:

MRF is a facility where recyclable municipal solid waste is processed and separated using manual and/or mechanical methods. Paper, glass, plastics, and metals are among the recovered items, which are baled, temporarily stored, and subsequently sold to recycling or manufacturing companies. The remaining of the residual material is subsequently disposed of in a sanitary landfill. MRFs can process either source-separated recyclables or mixed garbage, in which case the biodegradable components can be composted in another facility (ADB, 2013).

Materials recovery facilities (MRFs) were established in different *barangays* (community or village) of the Philippines to recover recyclable materials from municipal solid waste. These facilities, as required by the Ecological Solid Waste Management Act of 2001, were built using municipal finances, grants, and loans, but have had limited success.

- **Classification:**

MRFs can be classified in terms of inputs, capacity, and nature of waste processing:

TYPE	INPUTS	PROCESSING
Clean	Clean or source separated	Manual/mechanized
Dirty	Dirty or non-source separated	Manual/mechanized

Clean MRFs are typically built in towns or localities that practice high levels of segregation at the source and separate collection of biodegradables from non-biodegradables. A dirty MRF, sometimes known as a mixed-waste processing system,

Figure 34: Material recovery Facility
Source: (*What Is a Materials Recovery Facility (MRF)?, 2019*)

takes in a mixed solid waste stream and then separates out designated recyclable materials using a mixture of manual and mechanical sorting.

- **Parameters Considered in Planning, Design, and Operation of Materials Recovery Facilities**

- Nature of Waste Generators
- Waste Composition
- Waste Generation
- Waste Collection
- Waste Diversion
- Market Requirements
- Materials Recovery Facility Development and Operation and Maintenance Costs

- **Design of a Materials Recovery Facility**

A typical MRF is sited within a warehouse-type building with concrete flooring and enclosed by a perimeter fence for security. It should have the following components:

i. receiving or tipping area,
ii. sorting/processing area,
iii. storage area for recyclables,
iv. residuals storage area,
v. equipment area,
vi. space for an office, and
vii. Loading area for residuals and processed recyclables.

MRF Equipment	Intended Use
Weighing scale	Weighing of incoming waste and sorted recyclables
Weighbridge	Weighing of large quantities of incoming waste
Sorting table	Manual sorting and segregation of recyclables
Payloader	Loading of incoming waste into conveyor system, sorting tables; loading of baled recyclables into outgoing vehicles; moving of residual or biodegradable waste out of the facility into the adjacent disposal site
Conveyor with hopper	Receipt of waste from payloader and movement of waste for segregation
Conveyor system	Mechanized and regulated movement of waste for segregation
Trommel	Segregation of mixed waste or recyclables based on particle size
Magnet separator	Separation of iron-bearing materials
Air classifier	Separation of materials such as paper and plastic based on size, shape, and density
Baler	Compaction and binding of recyclables
Forklift	Movement of baled waste within MRF

Figure 35: MRF equipment

It should also have basic water and electrical connections, as well as enough room for waste trucks to enter and exit. Washing facilities and a septic tank are required. The warehouse design will reduce the placement of columns that could obstruct the efficient movement of products and equipment, as well as make higher ceilings easier to install.

Receiving areas should be able to receive at least two days' worth of the MRF's processing capacity in case of equipment failure and to provide materials for the second-shift operation if necessary.

Manually operated MRFs with capacities of less **than 2 tpd usually have roofed floor areas of at least 50 square meters (m^2),** which contain only the receiving, processing, and storage areas. Semi-automated to fully mechanized facilities would require areas ranging from **150 m^2 to 1,500 m^2**, excluding parking and buffer zones. The *Material Recovery Facility Handbook* of the Recycling Marketing Cooperative of Tennessee (2003) suggests a building area not exceeding **1,400 m^2** for MRFs that process less than **10 tons** of recyclable waste per day and about **1,800 m^2** of floor area for facilities that will handle waste not exceeding **100 tpd**. (ADB, 2013) .

Even for a manual operation, the basic equipment would include sorting tables, weighing scales, a baler, and a pay loader. Semi-automated MRFs employ a conveyor system that may be assisted by a loader to aid in sorting. Screens, magnetic separators, air classifiers, and conveyor systems with several processing lines are used in automated facilities. The equipment used will be determined by the target capacity as well as the nature and composition of the incoming waste.

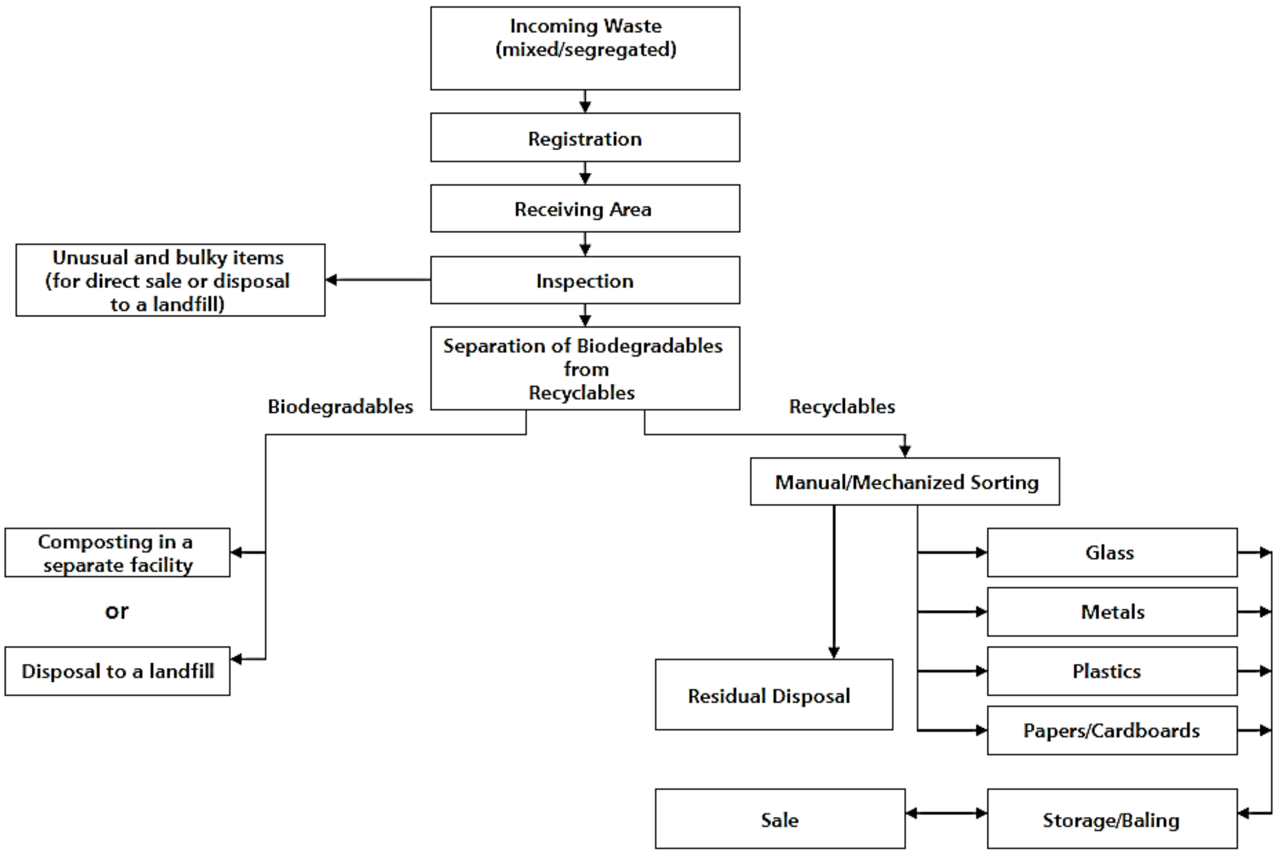


Figure 36: General MRF flowchart
Source: (ADB, 2013)

2.6.1.4 Compost plants:

After sorting waste into biodegradable, non-biodegradable, and residuals, biodegradables are composted. It can be performed through any of the digestion processes described below:

i. AEROBIC COMPOSTING

Aerobic composting is decomposition of organic matter using microorganisms that require oxygen. Composting bacteria are naturally occurring and reside in the moisture surrounding organic materials.

Left unattended, the organic fraction of MSW wills undergoes biological decomposition. The extent and duration of decomposition will be determined by the nature of the waste, moisture content, available nutrients, and other environmental conditions. Yard waste and the organic part of MSW can be transformed to a stable organic residue known as compost in a very short amount of time under controlled conditions (four to six weeks).

Aerobic composting is the most commonly used biological process for the conversion of the organic portion of MSW to stable humus like material known as compost. All aerobic composting systems have three main steps in common:

(1) MSW preprocessing,

(2) Aerobic decomposition of the organic part of the MSW, and

(3) Product preparation and marketing.

Aerobic composting takes about 8-10 days from start to completion. There is no leachate since any excess moisture is removed as water vapor, which can be condensed and used to water surrounding vegetation.*(“Aerobic Composting vs Anaerobic | Global Composting Solutions”)*

AEROBIC DIGESTION PROCESS:

Aerobic digestion is often done in activated sludge treatment plants. To improve the solids content, waste activated sludge and primary sludge are mixed and processed through a thickener. This considerably reduces the amount of material that must be treated in the digester. The technique is frequently performed in batches, with many digester tanks running at the same time. To maintain the contents well mixed, air is pushed into the tank and the contents are stirred. To reduce odors in works next to houses or capable of generating public nuisance, waste gases must be treated. The process of digesting is continued until the percentage of degradable solids is reduced to 20% to 10%, depending on local conditions.

ii. ANAEROBIC COMPOSTING

Anaerobic Digestion is a natural biological process that converts organic waste into combustible gas, which is a mixture of methane and carbon dioxide without the presence of oxygen (Moya, 2017).In addition, in comparison to the aerobic procedure, this treatment process requires less energy. Because biodegradable municipal waste has a large potential for energy production, AD can be an efficient technique for treating organic waste (Zafar, 2019).

Anaerobic digestion for biogas production occurs in a sealed vessel known as a reactor or digester, which is designed and built in a variety of forms and sizes based on the site. These reactors contain sophisticated microbial communities that break down (or digest) the waste and create biogas and digestate (the solid and liquid end-products of the AD process), which are discharged from the digester.

ANAEROBIC DIGESTION PROCESS:

The biomass to be treated is put into a digester via a loading process. Digesters are tanks built of reinforced concrete that can be round or rectangular. The major activity-anaerobic digestion (when biomass is turned into biogas) takes place within the digester.

The produced biogas is sent to a gasometer (a pressure-switch accumulator for biogas), which absorbs any changes in production. This ensures that the amount of power supplied is controlled by the rate at which biogas is produced.

Once the biogas reaches the engine, it is transformed into electrical energy.

The remaining waste left over from the entire process is called digestate and is made up of solid and liquid manure. It is collected in digestate treatment plant. This by-product can be used as an excellent fertilizer and can be used on fields instead of chemical fertilizers.

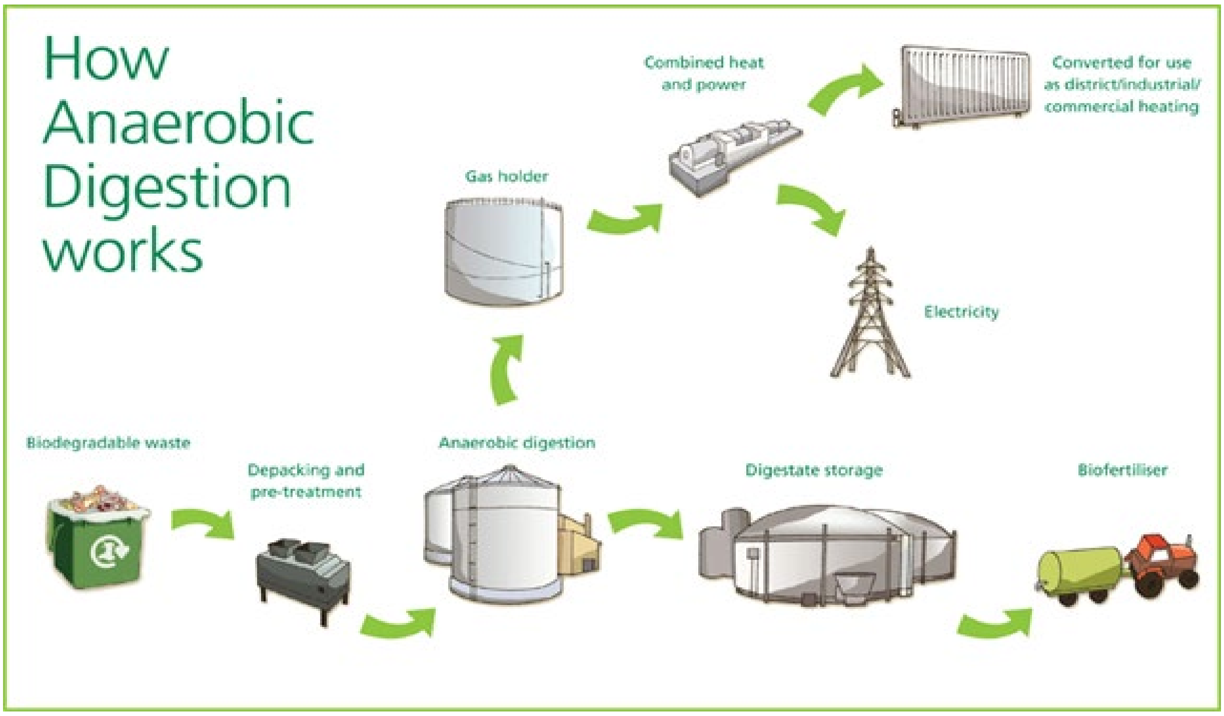


Figure 37: Working process of aerobic digestion

2.6.1.5 Plastic recycling unit:

Plastic recycling is the reprocessing of plastic waste into new products. Plastic collected from houses, companies, and local recycling centers is delivered to a Material Recovery Facility (MRF) that separates plastic and non-plastic, and/or a Plastic Recovery Facility (PRF) that sort plastic by kind. These facilities employ sorting equipment, such as an optical sorter, which can differentiate between various types of plastics. The plastic is then washed, shredded, and processed further at a reprocessing facility. After that, the plastic is melted and extruded into fresh recycled plastic pellets. These pellets are sold on to other companies for use in new products. Thus, the plastic recycling unit should be equipped with a technical room, processing room, recycling room, and miscellaneous rooms. (How is Plastic Recycled? A Step by Step Guide to Recycling)

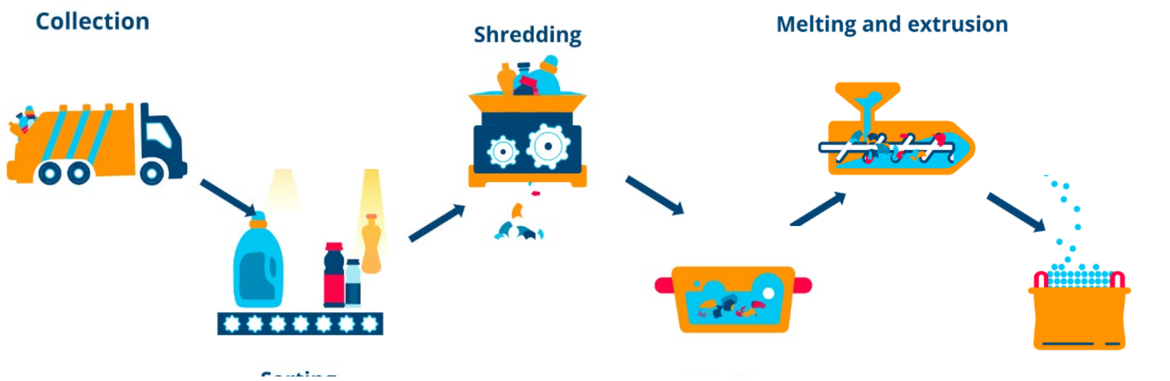


Figure 38: Plastic Recycling Process

Source: (How is Plastic Recycled? A Step by Step Guide to Recycling)

THE STAGES OF PLASTIC RECYCLING:

There are several phases involved in recycling plastic, which include collecting, classifying, and reprocessing the plastic so that it can be utilized in new products:

- **Collection** – plastic is deposited by the users into a recycling container
- **Sorting** – facilities sort plastic from other materials and also into the different types of plastic
- **Reprocessing** – plastic is washed, ground into flakes, heated and extruded into new pellets

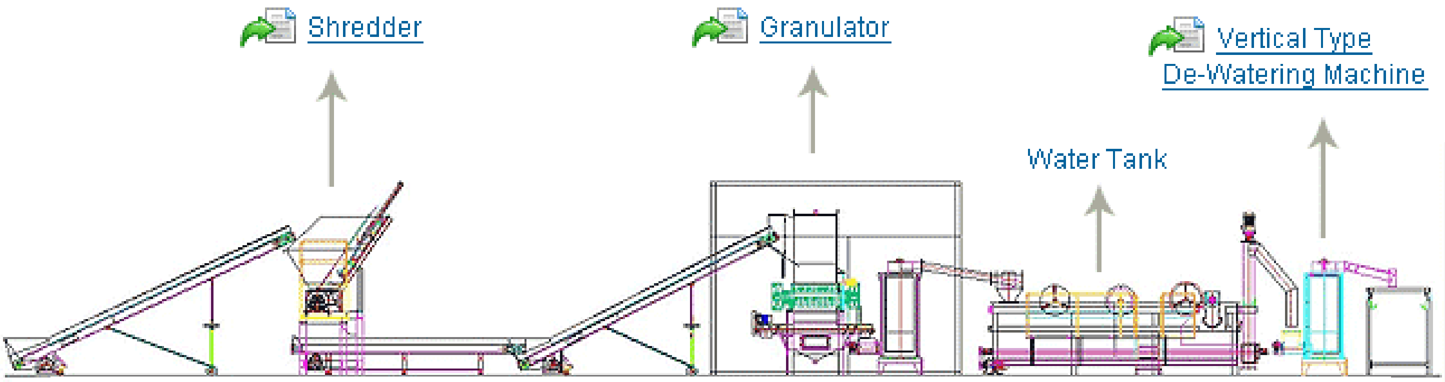


Figure 39: Plastic Recycling plant

Source: (*How to Start a Small Plastic Recycling Plant? Zhangjiagang Seven stars Machinery Co., Ltd.*)

2.6.1.6 Paper recycling unit:

The recycling of paper is the process by which waste paper is turned into new paper products. The waste papers are collected from sources or sorted out in MRF. The collected paper is wrapped in tight bales. Most waste paper recycling processes include combining used/old paper with water and chemicals to break it down. It is then chopped up and heated, which further breaks it down into cellulose strands, a type of organic plant material; the resulting mixture is known as pulp or slurry. It is squeezed through screens to remove any remaining plastic (particularly from plastic-coated paper), then cleaned, de-inked (ink is removed), bleached, and mixed with water. It can then be recycled into new paper. (How is Paper Recycled?)

Paper Recycling Process:

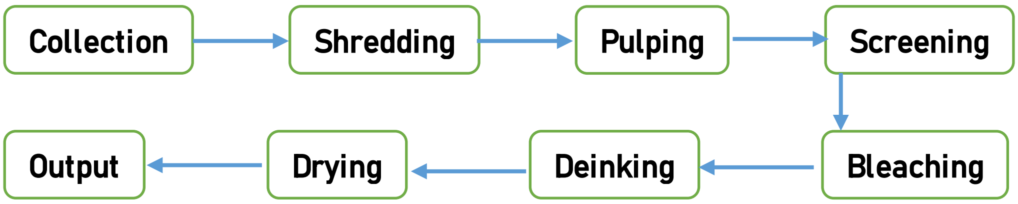


Figure 40: Paper Recycling Process

Source: (How is Paper Recycled?)

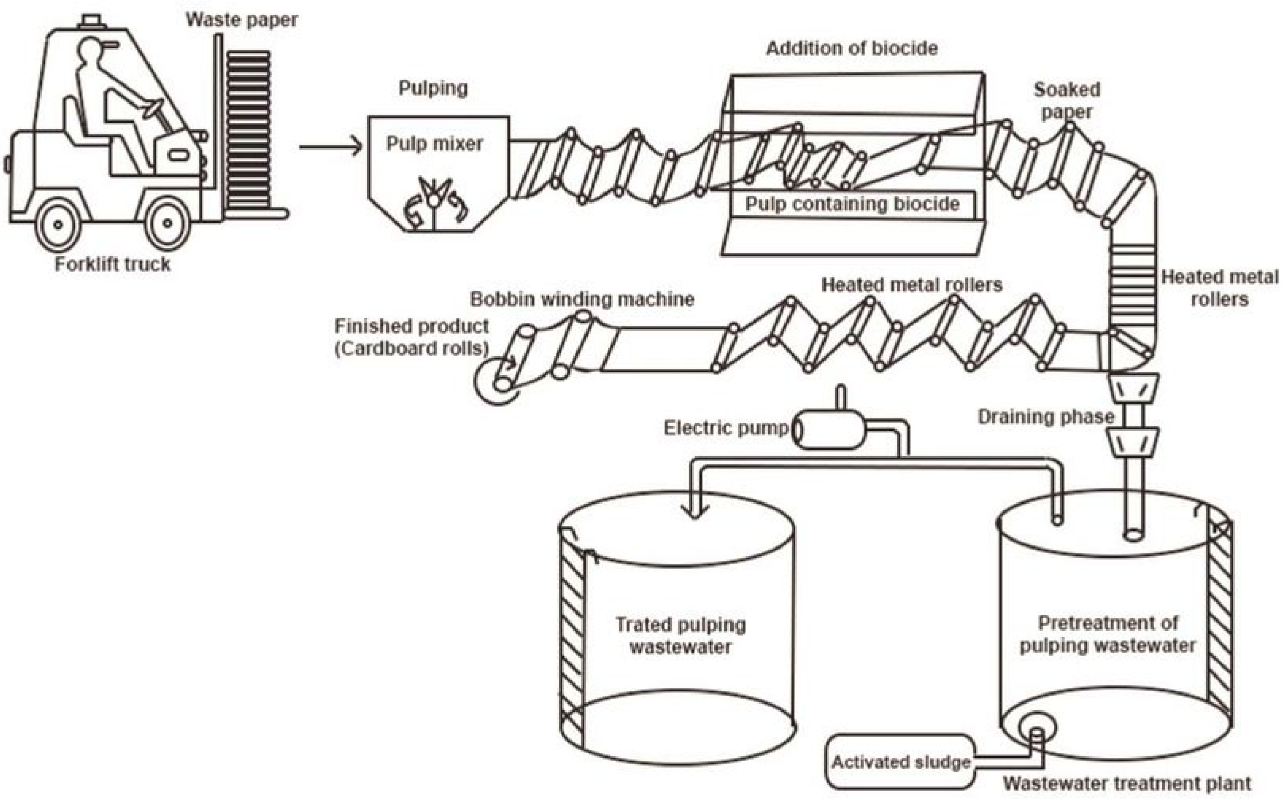


Figure 41: Schematic representation of a paper recycling facility showing the production of cardboard rolls as final product.

2.6.1.7 Glass recycling unit:

Glass recycling, also known as glass reprocessing, is the process which converts unwanted glass into useable items. This method involves washing, crushing, and melting discarded glass before reshaping it into bottles and jars. This cycle can be repeated indefinitely with no decrease in product quality.

The waste glass collected or separated from MRF is stored. The glass goes through a pre-treatment process that uses blowing air to remove any paper or plastic. Magnets are used to remove any metal things. It is then sorted by color and cleaned to remove any remaining contaminants. The material is then crushed, melted, and formed into new items such as bottles and jars.

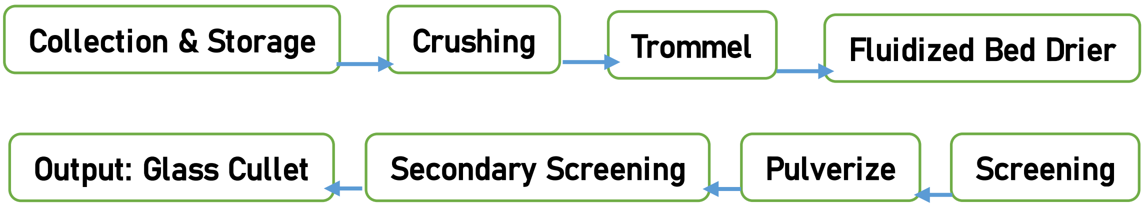


Figure 42: Glass Recycling Process

Source: ("Glass Recycling Process")

The final product Glass cullet can be used for manufacturing glass products or fiberglass and can be used as filler in paint and plastic or flux in ceramics.

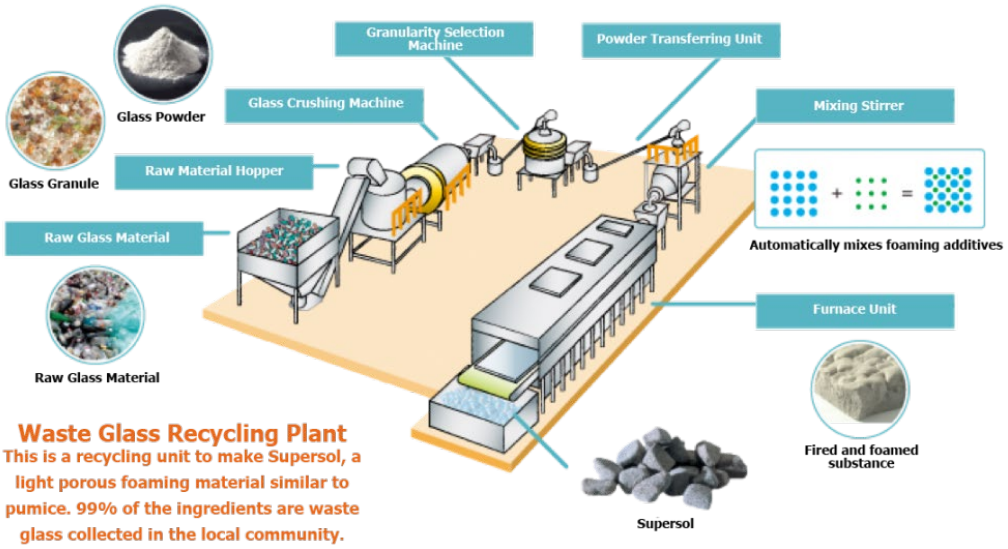


Figure 43: Waste Glass Recycling Plant

Source: (*Overview of the Factory (Waste Glass Recycling Plant) | TRIM*)

The other product that can be obtained from glass recycling is Super Sol. Super Sol, which is artificial porous- lightweight-foamed material (pumice), is produced by crushing, baking and foaming waste glass. Super sol production device is composed of 8 machines, such as raw material hopper/charging conveyor/glass crushing machine/cullet crusher/powder transfer apparatus/vibration sifter/mixing stirrer/firing furnace, and auto control device of respective machine. (*Overview of the Factory (Waste Glass Recycling Plant) | TRIM*)

2.6.2 Employee Facilities:

The quantity and quality of the product are determined not only by the sequence, precision, and efficiency of the industries, tools, and machines, but also by the person's proficiency, pride, and fitness-both mental and physical. In recent years, the development of factory design has become increasingly focused with employee comfort.

Employees and staff are a crucial aspect of any workforce, and the more motivated and well-treated the employees feel, the better the total results may be obtained from the factory. Thus, the working environment must be designed keeping the worker's needs and requirements in mind. Workers must be appropriately accommodated because working with waste is a risk to their health. The design must be able to both motivate and calm workers during breaks, thereby sustaining a positive working environment. The plant's space, light, and color will primarily define its mood, which will in turn affect the mood of the personnel, which will ultimately affect the plant's success.

▪ Flexible and private spaces both should he provided according to function and need of users.

▪ Maximum daylight without glare not only reduces power usage but also increases the productivity

▪ Dull and dim factories demotivate workers, thus bright and motivating colors must be intended in design.

Besides for employees working in waste recycling center need to be provided with following functions:

1. Administration- Office rooms
2. Changing and locker rooms
3. Washing facilities
4. Resting/breakout spaces
5. Toilet facilities
6. Disinfectant room
7. First aid room
8. Cafeteria
9. Research center and laboratories

2.6.2.1 Administrative office:

The administration consists of office area for various personals. The way in which office work is organized and roles are defined affects the requirements for office space. The space requirement per an employee clearly depends upon a number of factors: type of work, use of equipment, degree of privacy, level of visits made by outsiders and storage needs. The workstation floor area requirement are:

- Separate office: 8-10m^2
- Open plan office: 12-15m^2
- Work room: 8m2 floor area
- 1.5m^2 per employee

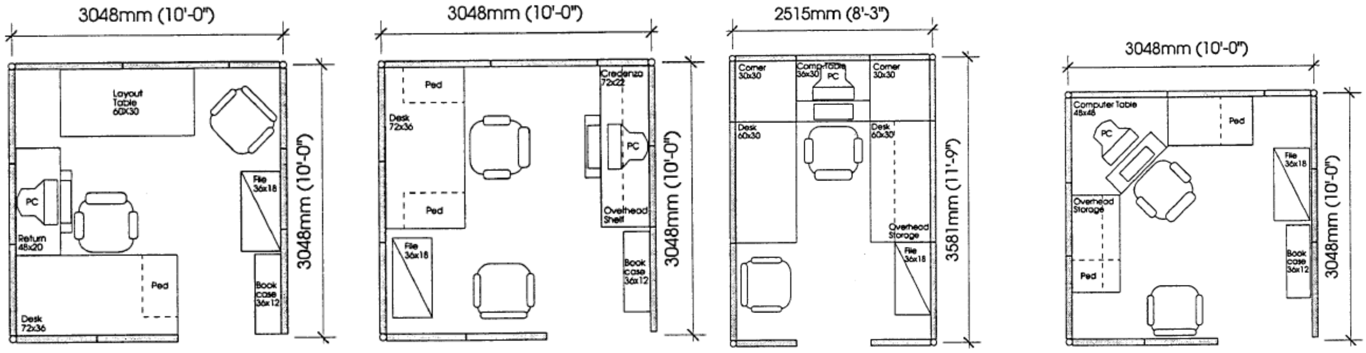


Figure 44: Office space Standards
Source: (Office Space Standards and Guidelines)

2.6.2.2 Toilet facilities:

To ensure a good working atmosphere it is essential to design sanitary facilities which are both functional and attractive. Toilets should be approximately 100m from each workstation.

Men							Women					
number of employees	flush toilets	urinals	troughs (m)[1)]	hand basins[2)]	additional flush toilets	additional urinals	number of employees	flush toilets	hand basins[2)]	additional flush toilets	waste bins	sink
10[3)]	1	1	0.6	1	1	1	10[3)]	1	1	1	1	1
25	2	2	1.2	1	1	1	20	2	1	1	1	1
50	3	3	1.8	1	1	1	35	3	1	1	1	1
75	4	4	2.4	1	1	2	50	4	2	2	1	1
100	5	5	3.0	2	1	2	65	5	2	2	1	1
130	6	6	3.6	2	2	2	80	6	2	2	1	1
160	7	7	4.2	2	2	2	100	7	2	3	1	1
190	8	8	4.8	2	2	3	120	8	3	3	1	1
220	9	9	5.4	3	3	3	140	9	3	4	1	1
250[4)]	10	10	6.0	3	3	4	160[4)]	10	3	4	1	1

Figure 45: Requirements of Toilet Facilities
Source: (Neufert Architect's Data)

2.6.2.3 Washing facilities:

Washing facilities include all amenities and rooms which are used by staff for maintaining personal hygiene. They include washrooms, shower area and bathrooms. The number of washing facilities depend on the type of company:

For 100 users:

- Doing clean work: 15
- Doing moderately dirty work: 20
- Doing very dirty work: 25

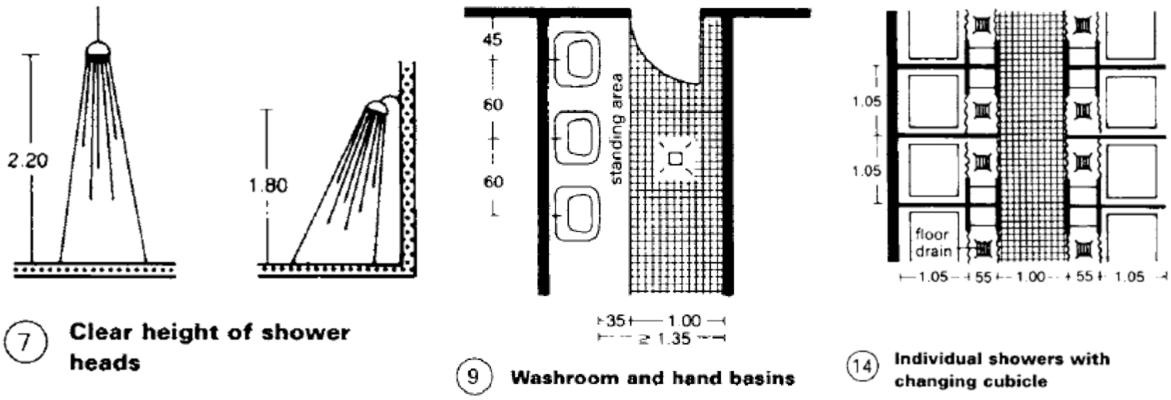


Figure 46: Standards for Washing Facilities
Source: (Neufert Architect's Data)

2.6.2.4 Changing rooms and locker

Changing rooms are amenities used by staff to change from outdoor clothing into work clothes and lockers are to store their belongings. They should be between the entrance to the factory and the working areas and be easily accessible. The basic floor area of a changing room should be at least 6m^2.Min changing area is 0.5m^2/ person. Washing and changing facilities must be in separate rooms that are directly linked.

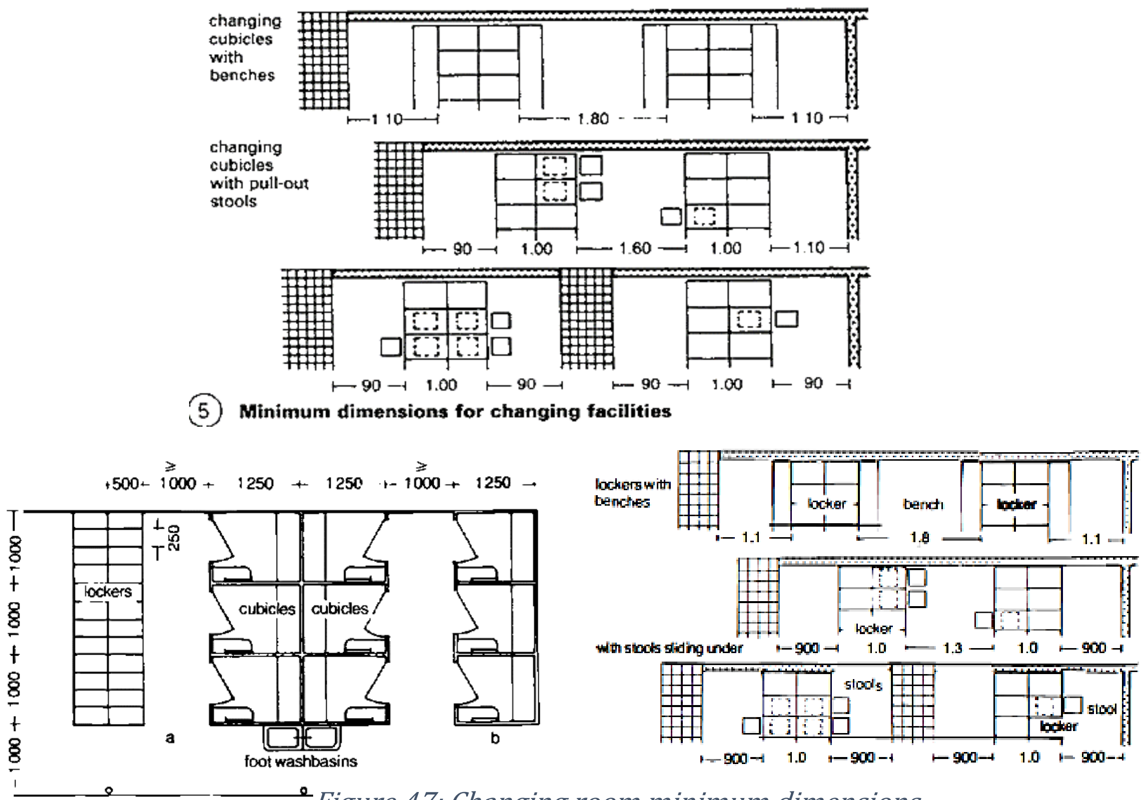


Figure 47: Changing room minimum dimensions
Source: (Neufert Architect's Data)

2.6.2.5 Cafeteria:

- Dining Room: 60% of total area
- Kitchen, cooking, storage, preparation: 40% of total area
- Storage: 1.5 to 2 times the kitchen
- Services aisles: 0.9 to 1.35m wide
- Area per person (dining room):1.2sqm
- Area per person (Kitchen): 0.24sqm
- Area per person (Store) :0.18sqm
- 1.5-2.7 sq. per seat for cafeteria

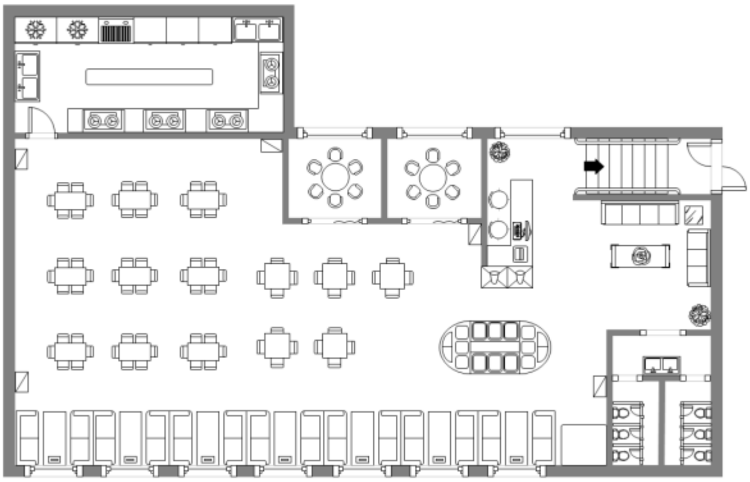


Figure 48: Cafeteria Design

2.6.3 Public Facilities:

Industrial structures, such as waste recycling facilities, are frequently secluded from public view. They are viewed as disconnected and neglected. Even when we think of an industry, we visualize a structure with CGI roof trusses that is unmaintained and unwelcoming. When we think of a waste facility, we see a massive pile of waste with a foul odor and a horrible view.

So, if only industries or waste management facilities could be designed in a way that the public could participate, it would add a new dimension to the architecture of such buildings. That means, the main concept is to design waste recycling collection centers not only for their service function, but also for public spaces across the city. Waste collection centers may be modified to include innovative approaches such as laboratories, markets, exhibition areas, and education.

Various research has been made in the Department of Architecture of the University Federico II in Naples, which focuses on a specific topic: **how the architecture and design of public space has a role in the planning of waste recycling centers**? The Harvard University has also made research entitled 'Architecture and Waste' that highlighted several examples and case studies of waste management facilities that integrate public functions to engage communities beyond their core function.

As a result, the research demonstrated the significance of public spaces and their participation in waste recycling centers in adding quality to such industrial buildings. It was realized that hybrid architecture, which merges waste and architecture through public engagement, brought new life into previously uninhabited and entirely forbidden public areas.

The various public spaces that can be provided in Waste recycling Centers includes:

- Community parks
- Education center
- Recycle pavilion
- Exhibition area
- Cafeteria

2.6.3.1 Community parks:

As community parks, public space for waste recycling can be provided for residents. They can be used for recreational activities such as jogging, children's play, and as a space for community interactions. Such community parks can be made educational, entertaining, and relaxing all at the same time. Such community parks can serve as a space for relaxation and recreation in the midst of an urban area, as well as learning spaces to promote the importance of recycling.

Figure 49: Idea to include community parks in Waste recycling Center
Source: (“Wikiwand - Shek Mun”)

2.6.3.2 Education center

Education center can be unique idea for public engagement in waste recycling facilities. Through it, people can learn about the concept and importance of recycling and how recycling can be done at source level. A visual connection to recycling centre can provide knowledge of recycling process as well.

Figure 50: Education Center in Sunset MRF, Brooklyn
Source: (*Sunset Park Material Recovery Facility / Selldorf Architects | Arch Daily*)

2.6.3.3 Recycle pavilion:

The concept of a recycle pavilion can be an innovative way to entertain and attract visitors. The pavilions can be constructed from recyclable materials. For example:

Cast & Place, which won the seventh annual **City of Dreams Pavilion Competition**, **"reimagines garbage as a transformative resource for our New York City future**." 250,000 aluminum cans are melted and placed in the cracked dredge. As a result, light, strong panels that give structure and shade are constructed into performance and play spaces.

PET Pavilion: PET pavilion, a temporary structure in a community park in The Netherlands that focuses on issues of sustainable building, recycling, and waste by rethinking the ways that buildings are developed, built, and used. Specifically, the pavilion is a study of the use of plastic waste as a building material.*(“From Recycled Plastic Waste to Building Material”)*

Figure 51: Concept of recycle pavilion
Source: *(“From Recycled Plastic Waste to Building Material”)*

2.6.3.4 Exhibition area:

Exhibition area can be great inclusion as public space in waste recycling centers. Various recycled products can be exhibited from with visitors can get knowledge for exploring new ideas of recycling.

Instead of striving to be a "sustainable" solution, the PET pavilion focuses on exploring new possibilities and serving as an educational tool. The overwhelming quantity of bottles utilized in the project, is intended to highlight the amount to which we consume products and generate waste, with the intention that visitors may question where their waste goes or how else it could be used for a new purpose.

Figure 52: Exhibition area
Source: *(“From Recycled Plastic Waste to Building Material”)*

2.7 INDUSTRIAL DESIGN

2.7.1 Architectural expression of industrial building:

Industrial architecture prioritizes a building's utility over its appearance, making it functionally ideal. Industrial architecture takes many forms depending on its purpose, but some common characteristics /elements found across the spectrum of industrial architecture include:

- Functional and design integration
- Large, open floor plans
- High ceilings
- Use of raw rough materials such as concrete, brick, metal
- Lack of ornamentation on building façade: Follow the modern architecture philosophy of prioritizing functionality over ornamentation.
- Large metal grid windows
- Exposed materials and utilities("Learn All About Industrial Architecture")

2.7.2 Industrial Building Components

There are a few general components of an industrial development, and it is vital to determine their behavior and requirements before designing the complex. The few components and design considerations are detailed further down: (Time Savers Standards for Building Types)

1. **Administration**

The relationship between management and organization must be worked out first. Before planning and design can begin, the number of staff in each department and the nature of each department's work must be determined.

2. **Employee facilities**

The attitude of the employees, which can be influenced by design, has a big impact on the success of a factory. Employee facilities should be close to the work area so that little time is wasted travelling back and forth, but they should also be sufficiently isolated from the sights and noises of the work area to provide a real change of scene. A nice working environment may make a significant difference in the factory's success...

3. **Manufacturing**

Various manufacturing parameters determine the amount of productivity in an industrial structure. The most critical factors for a productive atmosphere are material flow and degree of flexibility. In addition, the design must allow for easy expansion while working. To provide order and flow throughout the plant, the design must allow for employee movement and supervision.

4. **Research and central Facilities**

Laboratories are required in modern plant areas for research (product development) and control. In very big manufacturing facilities, the research and product development facility should be in a distinct building. Flexibility is mandatory in the layout of research and development facilities.

5. **Warehousing**

Since the warehouse is the first to feel the effects of expansion, it must be constructed to indicate the projected expansion program. It must be compressible and flexible. With modern technologies, automated warehousing is also possible. Design must reflect that storage at different times may differ, but must still be constructed with maximum capacity in mind, and in order to save space, can be created for flexible use.

6. **Internal Engineering**

Internal engineering should be chosen and prepared only after a feasibility analysis to determine the best suitable system. Internal engineering areas must be built 100 percent greater than originally required. Adequate room for mechanical and electrical installation is a primary and critical factor in industrial design.

7. **External engineering**

External integrated features all outside utilities and storage facilities such as parking, disposal sites, transformers, and so on. Because these are permanent and expensive installations, they should be planned for fixed space and placed along the fixed façade. (Time Savers Standards for Building Types)

2.7.3 Industrial Building Planning Guidelines

1. **Flow and Organization**

In a factory or manufacturing facility, numerous processes and tasks must be performed on a single working floor. The flow and arrangement of these functions are critical for an efficient working environment that produces the greatest results. A factory, such as a waste recycling facility, has a different management structure, yet efficient communication is equally crucial. As a result, the design of a factory must allow for a clear flow of functions and effective communication between workers and various levels of management...

2. **Worker's Perspective**

Nobody wants to work in a dull atmosphere, especially in an industrial environment where productivity is critical to success. It's critical to think about how space and light may be used to create a more interesting atmosphere, as well as how other design elements can be employed to create more inspiring surroundings.

(Wooldridge)

3. **Safety and Security**

Factories use a number of large machines and chemicals in the manufacturing process of the item being manufactured. These components have the potential to cause worker's direct physical harm. Various products of the plant may be dangerous to both workers and the environment. As a result, proper safety and security measures must be designed in accordance with the nature of the factory.

4. **Scale and Size of the Building**

Unlike many other buildings, the sheer scale of some manufacturing buildings can get large. As designers it is important to consider the visual impact of the design. One of the major aspects of designing factory/industrial building is to understand how the building will sit in its surroundings, how the building look from different angles, distances and locations and if it will add or hurt the visual integrity of the area. The environment must be protected, both physically and visually. Design must address the issue of scale and size, making as minimum of impact as possible on the surrounding and fulfilling the spatial requirements of the factory itself. (Wooldridge)

2.7.4 Industrial design considerations

Planning specific building sites for industrial developments requires a number of considerations which include criteria as discussed below.

1. Setback

Building setbacks between the building and the street in front will vary depending on where the building is located on the property line. If vehicular parking is permitted only on one side of the buildings, 40 to 45 ft. should be provided for the driveway and parking spots. If parking is permitted on both sides of the driveway, allow 60 to 65 feet. Side and rear building setbacks are often fewer than front setbacks and are determined by national building codes.

2. Truck loading and maneuvering

Truck loading and maneuvering depths from edge to edge of the maneuvering area vary based on the anticipated traffic in the industrial plant. A successful warehousing operation can occur with as little as 85 ft. of truck docking and maneuvering depths, although the required depth for trucking terminals for larger vehicles (45-ft trailer length) is as much as 129 ft. As a result, maneuvering depths vary depending on vehicle flow, frequency, and vehicle size.

3. Vehicular Parking

The number of users and visitors in the industry directly influences parking area and size. The number of parking spots required is directly determined by the travel habits and modalities of users. Generally, if one aisle, 75 feet should be allocated for parking and planting and parking spaces on either side are deemed adequate. It is advised that designers reduce parking areas to a minimum while leaving room for future development as demand grows. Storm drainage plans must also be considered while creating parking spots.

4. Building coverage

Making the most out of the building coverage to maximize the value of your investment is a popular trend these days. However, when creating functions on-site, building bylaws such as building coverage, zoning, and FAR must be followed. Before considering economic gain in any design, laws must be followed.

5. Traffic generation

Understanding the nature and extent of traffic generated by various land uses is critical for industrial site developers in order to provide suitable roads. We can forecast traffic generation and construct a road network to support such traffic based on some standard data. (Time Savers Standards for Building Types)

2.7.5 Industrial Design Features:

1. Story:

Larger heights and single-story architecture, sometimes with balconies and/or a basement, are typically employed in industrial buildings when the product is huge and heavy, and the weight of machinery generates heavy floor loads. This type of structure requires a large, more or less open area. Multi-story buildings are employed in industrial projects to improve economic value or rent out space above.

2. Shape of building

When there are frequent changes in product design or rearrangement of layout, a regular form building, such as square or rectangular, is chosen. Building material restrictions or a desire to reduce the number of materials utilized can significantly affect the building shape. Other shapes or separate buildings are generally used due to physical constraints such as land and property lines. Buildings with a lot of odor and noise use irregular shapes and forms to screen out undesired disruptions from various viewpoints.

3. Basement or balcony

Basements can be a highly valuable element in a variety of designs and offer numerous alternatives, particularly on sloped ground. A basement design should include enough headroom, adequate ventilation, sound foundations, adequate lighting, and waterproofed walls and flooring that are free of groundwater seepage or flooding. Balconies are typically utilized for subassembly operations with final assembly of large pieces on the ground level or assembly operations with heavy shaping machinery below.

4. Windows

When placing a window in an industrial building, various considerations such as brightness or glare, angle of light-morning and evening, winter and summer, heat effects to employees and/or materials from sun on windows should be considered. Windows must also be resistant to wind, stress, fire, acids, and corrosion. Windows should also be easily accessible for cleaning and/or repair.

5. Floors

Workers in industries are likely to have to stand for lengthy periods of time or walk around a lot. Foot tiredness among workers must be considered. It might be avoided by including wooden or rubber matting in the design. The concerns of dropped pieces being damaged and rearrangement being difficult can be addressed by covering the concrete with wood block, wood flooring, composition block, or coating. Floors must be robust enough to support machines and equipment while still being economical to build. It is critical for floors to be shock resistant, abrasion, heat conductivity, vibration, and should not be slippery under any circumstances Floors are preferable when they are noiseless and sound absorbent, as well as visually appealing.

6. Roof and ceilings

Roofs and ceilings are affected by their type of construction and or nature of building. Depending on the weight bearing capacity required, different roof designs can also provide useful spaces underneath specific types of roofs.

7. Wall and column

When various operations must be separated, partitions are created that must be easily inserted and removed. They can be built as high as needed to shield or protect the area, or they can be suspended from the ceiling. Walls supported by ceilings keep the floor area clear but trap fumes, noise, and heat and the like from spreading throughout the structure. Wall openings must not be disregarded. Even without interior walls, columns are needed for roof support. Columns often cause two major issues:

- Limits the basic flow pattern
- Creates obstruction

2.8 DESIGN CONSIDERATIONS:

Based on the literature review, the following points can be concluded as design considerations to be made when designing the waste recycling center.

1. **Functional layout of plants**:
   The planning and functional layout of the industrial building are governed by the arrangement of machines and the flow of services.
2. **Hybrid architecture**: By rehabilitating existing functions and integrating them with new functions for the community, a hybridized recycling facility with public engagement activities can be designed.
3. **Segregation of waste from the direct view of sight from public:** The design must ensure that no public has direct contact with the waste in order to prevent health hazards.
4. **Architectural expression of industrial building:**

The design of an industrial building can vary depending on its purpose, but there are some common elements found across the spectrum of industrial architecture.

- Wide-open spaces
- Minimalist aesthetic.
- Exposed materials and utilities
- Natural light:
- Metal-grid windows or floor-to-ceiling windows.

5. **Sustainability approaches:**

Various sustainable approaches can be integrated in the design such as

- Rain water harvesting
- Solar panels
- Green roof

6. **Lighting**

   • Industrial architecture must make efficient use of natural light through large metal grid windows or floor to ceiling windows. Because natural light is the best for working, optimal natural light must be ensured within workplaces, so window size and placement must be considered.

   • Furthermore, the intensity of natural lighting cannot be controlled. As a result, artificial lighting is required to supplement natural lighting.

7. **Accessibility: the design must** ensure free movement of workers within the spaces
8. **Noise and smell control:**

   Sound and smell insulation must be prioritized in design of such waste recycling facility so that there is no negative impact on the surrounding environment or society.

3. CASESTUDIES

3.1 NATIONAL CASE STUDIES:

3.1.1 TEKU TRANSFER STATION:

➢ **INTRODUCTION:**

- Location: Teku, Kathmandu
- Site Area: Approx. 40 ropanis
- Project Type: Waste Transfer Station
- Access: Roads Around the Site With 3 Entry /Exit Point

Figure 54: Site plan of Teku Transfer Station
Source: Google maps

Figure 53: Pile of waste in Teku Transfer station

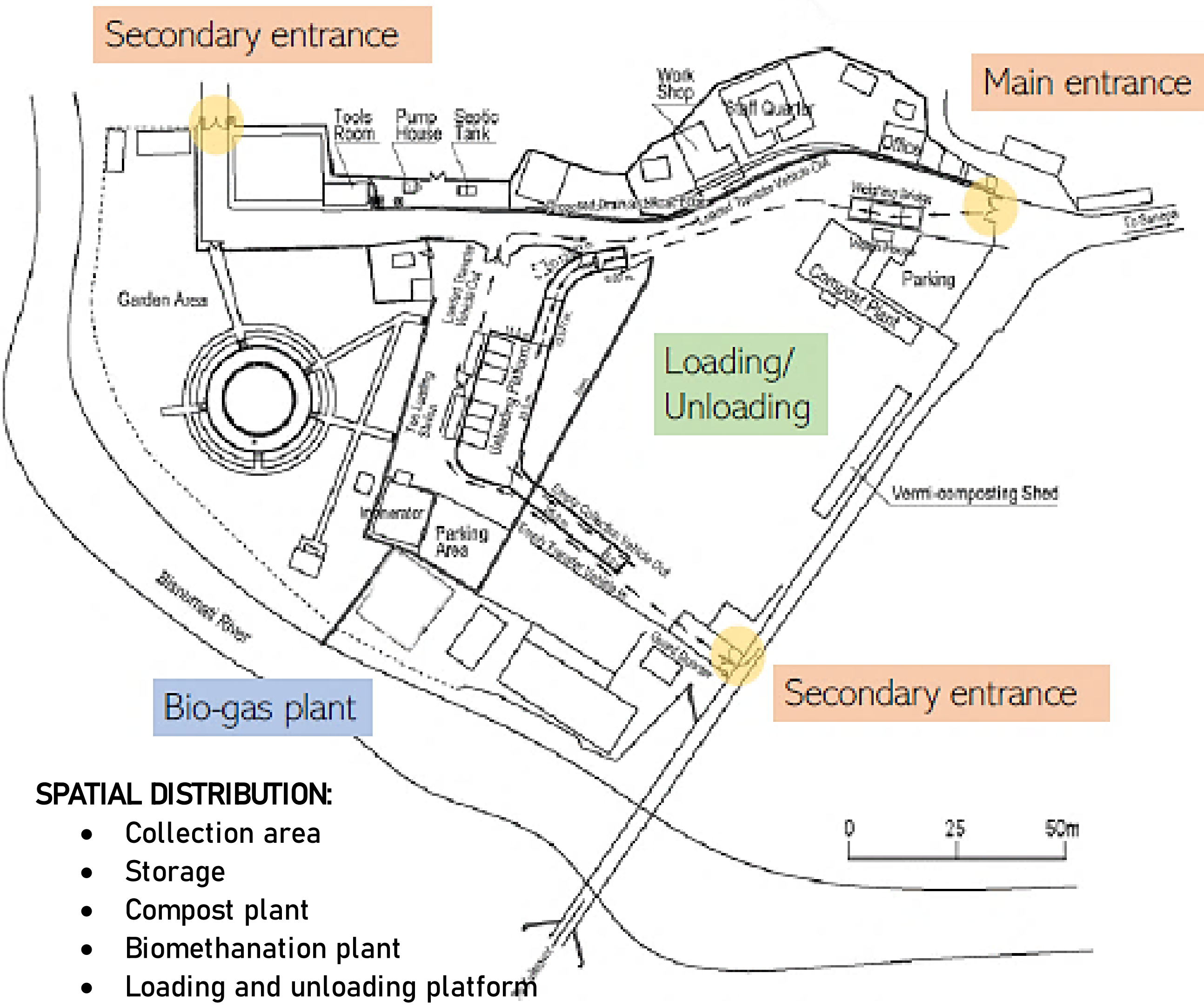
➢ **PURPOSE OF THE STUDY:**

- To observe and understand waste collection and transfer system of Kathmandu valley.
- To understand the design strategies and analyze the suitability of plan in context to the surrounding.
- To understand the problems faced by employees and neighborhood due to this facility.
- To understand the modality of loading /unloading of wastes
- To understand the relation of spaces to the function of treatment plants.

➢ **BACKGROUND:**

The SWM Act section 11, states that the local body may fix any location as a transfer center to manage the solid waste collected at the primary site taking into consideration that the environment and public health shall not be adversely affected and the necessary provisions shall be made to manage the site against the bad odors. The KMC operated one transfer center in Teku with a capacity of 10,000 tons in an open area surrounded by residential areas. (Solid Waste Management of Kathmandu Metropolitan City, 2015)

Teku transfer station was opened in 1986 and was designed as an integrated waste management facility with sustainability as center for collection of the waste from all over the Kathmandu, Bhaktapur and Lalitpur. The collected waste is first transported to the Teku Transfer Station, where it is separated, loaded onto larger vehicles, and transported to the Sisdol landfill site. The transfer center was originally constructed with infrastructure for segregating various wastes and composting organic waste. It consists of the spaces for compost plant, vermicomposting stations and bio gas plant for more sustainable waste management and are in workable conditions. There is also garden area which seems to have been designed for the public to come and stroll. Other space distributions include tool room, pump house, workshops, staff quarter, offices and parking area for trucks and private vehicles of employees.



SPATIAL DISTRIBUTION:

- Collection area
- Storage
- Compost plant
- Biomethanation plant
- Loading and unloading platform
- Office rooms
- Staff quarters
- Garden area

Figure 55: Master plan of Teku Transfer Station
Source: (NIPPON,YACHIYO, September 2005)

- **PRESENT CONDITION OF TEKU TRANSFER STATION:**

Transfer station was visited by the audit team on August 22, 2014. It is observed that in transfer center vehicles collecting waste from the sources unload onto the ground and then it is scooped up again by using excavators and placed into a large vehicle and transported to Sisdol landfill. The transfer center was originally constructed with infrastructure for segregating various wastes and composting organic waste. In 2017, a biomethanation plant at the Teku transfer station converted **three tons** of bio-waste per day into electricity, and compost plants were successfully piloted throughout the Valley, but the technology has not been scaled up or improved for site-specific solutions depending on the nature of waste and the resources available.

It is observed that those infrastructures are not in used due to managerial problems. Being unable to use constructed infrastructure KMC could not strengthened the waste handling efficiency, reduce the transportation cost to landfill site and generate revenue from use of waste resources. The nearby people have complained that they are suffering from much health-related problems like symptoms of vomiting, allergy, respiratory problem, bad odor etc.

During the audit interview was taken with 48 persons living within 300 m. around the transfer center. Among them 100 % has said foul odor, 98% has agreed with environment degradation around the center, 92% has suffered respiratory or other health problem, 94% has said the KMC has not provide health care service to them, 98% has said the KMC could not collect waste in time and 96% has recommended to close the transfer center. (Solid Waste Management of Kathmandu Metropolitan City, 2015)

- **Conclusion:**

The KMC should run the existing infrastructure for waste separation and composting in accordance with environmental rules. At the transfer station, the appropriate resources should be provided for waste segregation and recycling. A feasibility study to convert the open transfer facility into a closed one by creating the necessary infrastructures, should be conducted and enough measures need to be made to prevent foul odor and leachate discharge.

Strengths	Weaknesses
• Variety of facilities are available for waste management • Designed with provision of garden to have public involvement	• Facilities are not realized to their capability • Located in middle of the city. So, odor and traffic causes disturbance to the public. • Not recycling even though there are means and manpower available. • Wastes mishandling has led to pollution of Bagmati river flowing alongside site

3.1.2 VENTURE WASTE TO ENERGY P. LTD. (VW2E)

➢ **INTRODUCTION:**

- Founder, CEO: Janesh Shrestha
- Location: Panmara, Ward-6, Dharan Sub-Metropolitan City
- Site area: APRROX. 22000 SQ. M (4 ropanis)
- Project type: Waste to Energy Project through Anaerobic Digestion (Biogas)

Figure 56: Venture W2E, Dharan SMC
Source:

➢ **PURPOSE OF STUDY:**

- To study organic waste recycling process
- To study space allocation required for various process.

➢ **BACKGROUND:**

Venture Waste 2 Energy (VW2E) is the first Municipal Solid Waste Management project at Dharan Sub-Metropolitan city focused on sustainable growth in renewable energy sector. It is a private limited business with the goal of developing a waste-to-energy plant using anaerobic digestion. The purpose of this VW2E is to create environmentally friendly solutions for processing organic feed waste from any source while also contributing to the country's economic growth.(*Venture Waste 2 Energy*)

One of the major products of the project is bio-methane gas which they aims to sell it to the domestic and industrial consumers in Nepal. The project aims to manage municipal solid waste from Dharan Municipality and use organic waste as energy source through Anaerobic Digestion. The capacity of the plant is **30 TDP (Ton per Day**).

This project is using the **SERI Organic Fuels Technology** which is a multi-stage variable hydraulic and solid retention, microbe incubated Bio-Reaction system. This technology uses the "microbe incubated Bio-Reactors (MIBR) with stabilized incubation system and laboratory cultured feed specific microorganisms and related biotechnology and fast breeder media". This technology can process any organic feedstock like fruits and vegetables waste. Not only organic feedstock, it also processes agricultural waste, oil effluents, poultry and fish remains etc. One of the major advantages of this technology is that it processes 100% of waste processed.

The output of this projects are biogas, organic fertilizer, pest repellant and recycling scraps. The information provided above are all based on the Detail Project report submitted by Venture Waste to Energy P. Ltd to Office of Investment Board. (‘INTEGRATED SOLID WASTE MANAGEMENT PROJECT’)

Figure 57: Organic waste being converted into energy through a process called anaerobic digestion at Ventures Waste to Energy's station in Dharan.

Source: (@therecord)

Strengths	Weaknesses
• Innovative technique adopted to manage organic waste. • Capacity: 1,200 kg of biogas/day by processing 30 metric tons of MSW.	• No specified area allocation for specified function • Only consideration to technicality, not considered from the view of architecture.

- **INFERENCES:**

• Proper zoning and space allocation based on function is essential.

• It is critical to design such waste management facilities both architecturally and technically. Thus, in the design of such a waste management facility, both architectural and technological aspects must be equally prioritized.

3.1.3 HIMALAYAN LIFE PLASTIC RECYCLING PLANT

➢ **INTRODUCTION:**

- Founder, CEO: Daniel Burgi
- Location: Pokhara Industrial Area, Pokhara
- Site area: Approx. 22000 SQ. M (4 ropanis)
- Project type: Plastic Recycling center

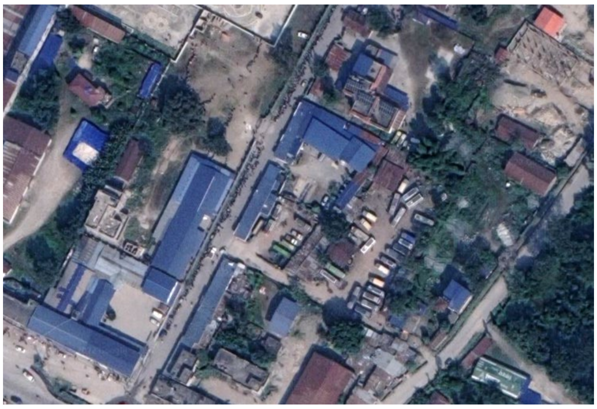


Figure 59: Site Location of Himalayan Life Plastics
Source: Retrieved from Google earth

Figure 58: Collection area
Source: ("Mountain Plastic Recycling Plant In Nepal Himalayan Life")

➢ **PURPOSE OF THE STUDY**

- To study available infrastructures in Nepal for waste recycling.
- To study the architectural requirements and spaces of plastic recycling factory
- To learn how recycling and vocational training program go hand in hand.
-

➢ **BACKGROUND**

Himalayan Life Plastics Recycling Plant is Nepal's only PET plastic bottle recycling plant, recycling over 40 million bottles per year and producing the best quality food-grade PET pellets. This is a social enterprise that buys PET bottles from Kathmandu, Pokhara, Syanjha, Tanahu, and Langtang and recycles them to generate the finest quality plastic granulate for bottle production. It employs more than 60 people and has over 250 collectors. This factory also houses the Himalayan Life Vocational Training Program, which has up to ten trainees and so has a good impact on Nepal's economy and ecology.

It is located in the Pokhara industrial area on flat ground with a south orientation, with two access points, one for vehicular entry where waste bottles are inlet and one for pedestrian which is also the main entrance for visitors and staff. The courtyard with garden, Cycle Park and sitting area are linked with workshop space, office space, processing room on three sides and kitchen and restroom, staff room on the back side to create a welcoming space.

The structure is a one-story rectangular structure with abundant daylight entering all rooms. Proper space zoning has resulted in an ongoing process of storing waste bottles in the backyard in the direction of vehicular access. Approximately 20 tons of compressed bottles and 5-10 tons of loose bottles can be stored. East of the main structure is a staff area, restroom, and kitchen. The waste water collection tank, located on the building's north side, is used to reuse water after the washing process. Each day, approximately 7000 liters of water are required for the recycling process, where an underground water filter is installed to purify and reuse the water.

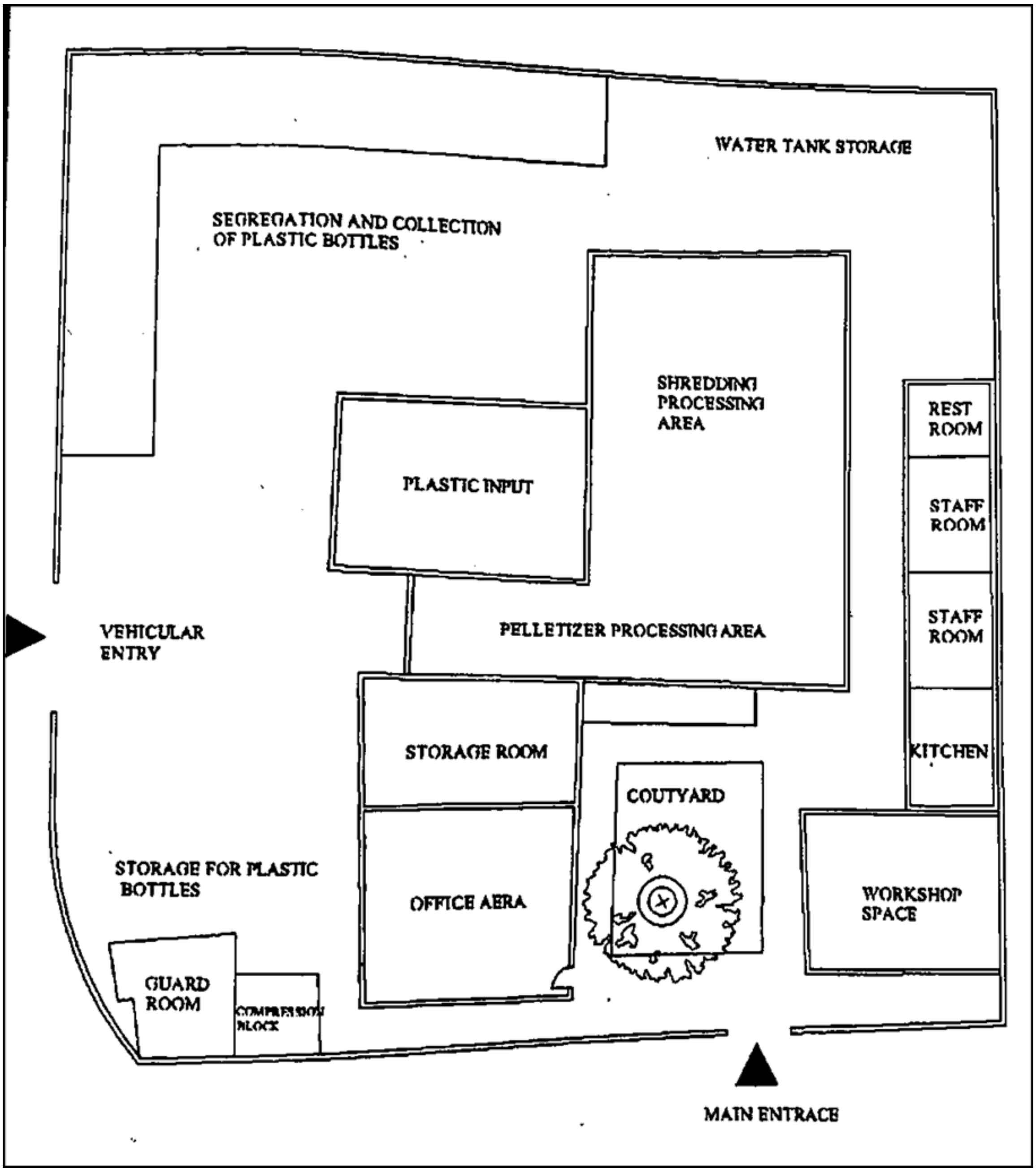


Figure 60: Floor plan of Himalayan Life Plastics
Source: (Shrestha, 2019)

The space contained by the building complex is listed below:

- Collection area
- Flex manufacture section
- Pellet manufacture section
- Storage
- Office rooms
- Training rooms
- Control rooms
- Kitchen
- Guard house

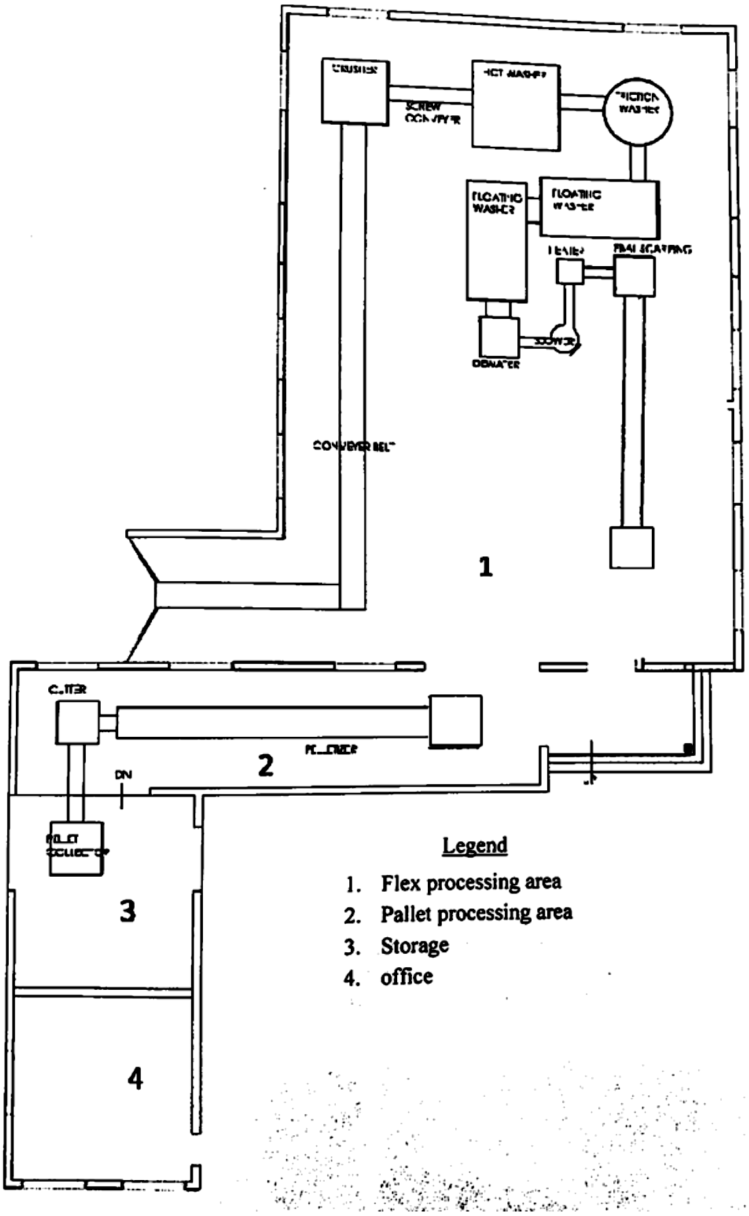
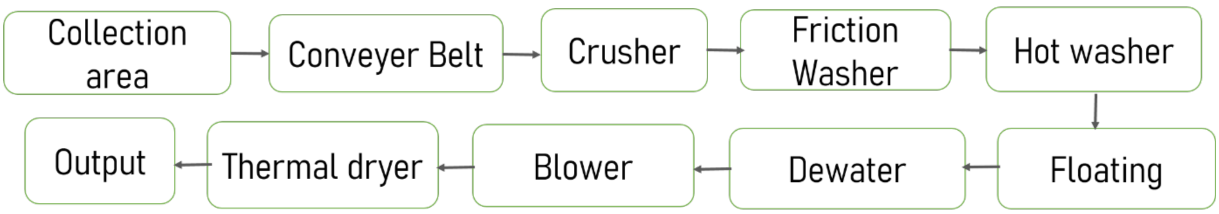


Figure 61: Processing Unit of Plastic

Source: (Shrestha, 2019)

Flex processing area:

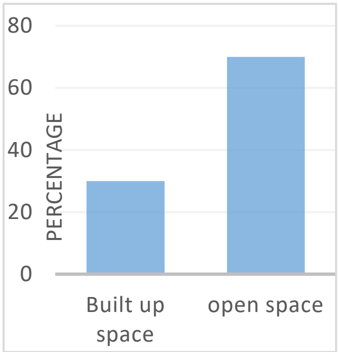


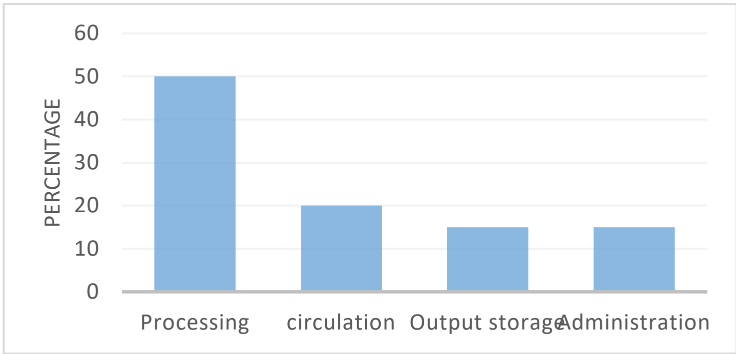
The waste plastic bottles are collected in collection area from waste collecting vehicles and trucks and stored. It is inlet through conveyor belt to crusher and then passed through shredding machine, friction floating and washing process and to dewatering tank. The flex is obtained as final product.

Pellet processing area:

In this process the flex is processed into plastic pellets where the shreds are melted at about 240 degrees then wire like plastic is generated and finally it is cut into pieces to form pellets and store in storage room, packing in 25 kg each.

Space comparison:





Strengths

- Good flow of circulation and proper planning equipment room making collection, processing more efficient
- Well-ventilated and well-lit making working conditions more favorable
- Considerations made to employee's facilities.

Weakness

- Sound insulation not provided while machines in plant produces around 85 dB causing noise pollution.
- Roof of CGI sheets causes rise in interior temperature at day time causing difficulty in working.

INFERENCES:

- A recycling plant's circulation and zoning of various components is critical.
- The architecture of the building must consider exterior environment since this plant includes several pollution-causing components.
- When passive architectural methods are incorporated into the design of the building, industrial architecture can become more sustainable.
- The design must have adequate acoustic insulating insulation.
- A better working environment for employees leads to higher productivity.

3.1.4 GENERAL PAPER AND PAPER PRODUCTS

- **INTRODUCTION:**

- Location: Hattiban, Lalitpur
- Site Area: APRROX. 32022.6 SQ. FT (5.5 ropanis)
- Project Type: Industrial
- Year: 2012
- Ownership: General paper and paper products Pvt.Ltd

Figure 62: Site Plan of General Paper & Paper Products
Source: Retrieved from Google Earth

- **BACKGROUND:**

General Paper & Paper Products Pvt. Ltd. is a manufacturer of pitch board. The company is located in Hattiban and it operates all over Nepal. The site is on flat land and located in residential area, the site has only one access for both vehicular entry for pedestrian.

Figure 63: General Paper & Paper products

The factory consists of collection area and processing space. The building oriented toward north direction. Office space, kitchen and staff room is toward west direction where storage of waste paper and drying of recycle paper is directly viewed from main entrance.

Since water is needed to make pulp of waste paper so approx. 10000-12000 liter is inlet by pumping water from well or boring. Since drying space is important in order to get

Figure 64: Collection area

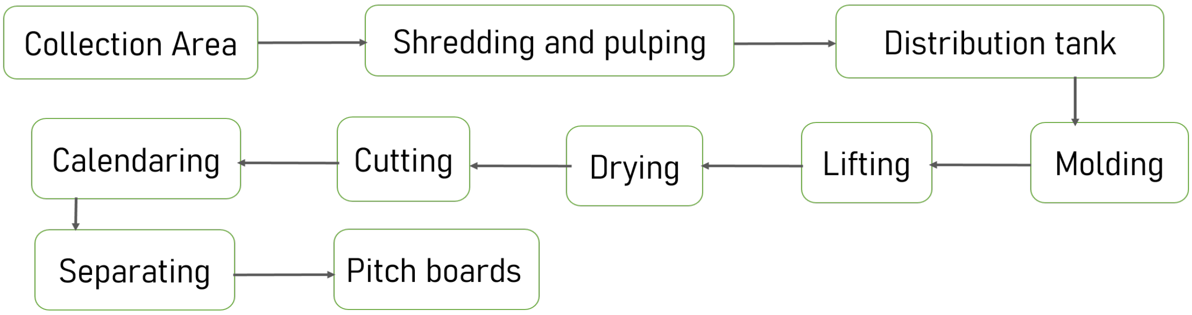
SPATIAL DISTRIBUTION:

- Collection Area:
- Shredding and pulping area:
- Distribution tank:
- Molding machine:
- Drying area:
- Storage:

maximum sunlight, rather than other spaces, drying space is placed in southern side where maximum sunlight can be gained for 7 days to dry paper.

The overall process of recycling of paper includes:

Recycling processing area:



Material flow Process:

1. **Collection Area:**

The waste collection vehicle collects waste paper from the surrounding area and scrap dealers in an open area near the building. Here, collected waste paper is manually broken into chunks pieces. Staff tear the waste papers and store it on the side of the main processing room. On average, 90 tons of rubbish are collected per month, at a cost of Rs. 10 per kg for ordinary waste paper.

2. **Shredding and pulping:**

After sorting, the paper is shredded to break it down into small fragments. The huge space was designated for the storage of shredded paper. A large amount of water is applied after the material has been finely shredded. The resulting slurry solution, known as pulp, has an oatmeal consistency and is used to manufacture paper. Pulping is the process of converting recovered paper resources to pulp. The pulp is then run through a series of screens and a centrifuge-like process to remove bigger impurities from the recycled paper, such as paper clips, staples, tape, and plastic films. The pulping process, also known as the beater process, required an underground pulping tank with a total volume of 12.5 cubic meters and a maximum inlet capacity of 12000 liters for the pulping process. It takes approximately 5 - 10 minutes to finish the beater process.

3. **Distribution tank:**

This process pumps the resulting slurry solution, known as pulp, into two distribution tanks, each with a capacity of 5000 liters, and distributes the pulp to three molding machines through a pipe line.

4. **Molding machine:**

The resulting slurry solution, known as pulp, is passed from the distributing tank and molded into paper with dimensions of 28-inch x 32-inch, with this machine producing 3000 Kg or 3 tons of paper per day.

5. **Lifting process:**

The molds paper are then lifted for drying process.

6. **Drying process**

The drying process is given the most space. Because the process requires sunlight, this location has the most sunlight while the other spaces, such as the processing area, office, and so on, have the least.

If the paper is exposed to direct sunlight throughout the day, the drying process takes 7 days. The tray for drying paper is designed to maximize paper drying or production. There are 70 trays, each with four compartments in which 120 paper sheets can be dried. If started on the same day, 33600 sheets of paper can be dried per week.

After drying, the paper are taken for cutting, calendaring and separating process. Calendaring is the process by which the surface of the paper is rendered less fibrous and spongy in appearance. This is accompanied by means of pressure applied to the paper at the end of its manufacturing process.

7. **Finishing process:**

The paper edge is cut in this process, and the final product is stored after being separated by weight. The waste paper after cutting the edge is also recycled in the same method, resulting in zero waste from this recycling procedure. Finally, the paper is placed in the storage room.

Strengths

- Good flow and zoning of spaces for circulation and processing.
- Receives proper light
- Provision of well/boring water required to make pulp

Weakness

- Roof of CGI sheets causes rise in interior temperature at day time causing difficulty in working.
- Unmanaged & No consideration to public amenities and employees

INFERENCES:

- Well planned circulation and zoning of different components is crucial to any design of waste recycling facility.
- Lighting and ventilation plays vital role in creating better working environment.
- Adequate consideration need to be provided to local environment so that no adverse effect is caused.
- Sustainable design approach and green building techniques need to be adopted.
- Staff and public facilities need to be properly addressed.

3.2 INTERNATIONAL CASE STUDIES

3.2.1 SUNSET PARK MATERIAL RECOVERY FACILITY

➢ **INTRODUCTION:**

- Architects: Selldorf Architects
- Location: Brooklyn, NY
- Area: 140000 ft²
- Project Type: Industrial, Material recovery
- Year: 2014

Figure 65: SUNSET PARK MATERIAL RECOVERY FACILITY
Source: (*Sunset Park Material Recovery Facility / Selldorf Architects | Arch Daily*)

➢ **ABOUT:**

The Sunset Park Material Recovery Facility is a waste processing center for New York City's curbside metal, glass, and plastic recyclables which is being operated by Sims Municipal Recycling and the City of New York. It is located on an 11-acre waterfront pier in Sunset Park. It was designed by Annabelle Selldorf and its construction involved the use of a variety of recycled materials. The design was influenced by its programmatic use as a recycling center which inspired reuse throughout.

The concept of masterplan of this recycling facility organizes buildings to support functionality, develops unique circulation systems to safely separate visitors from activities, and includes two acres of natural vegetation. Buildings are also organized to create the site's own urban context. This facility includes:

- **A Tipping Building**, where recyclables arrive by barge and truck;
- **Processing Building** that houses complex sorting equipment, as well as electrical compressor, fire pump, and supervisor rooms;
- **Bale Storage** Building served by eight loading docks; and
- **Administrative**, a building for personnel (lunch room, locker rooms, offices) and
- **An Education Center**, Center contains programs for students and the public including classrooms, exhibitions, and interactive demonstration displays.

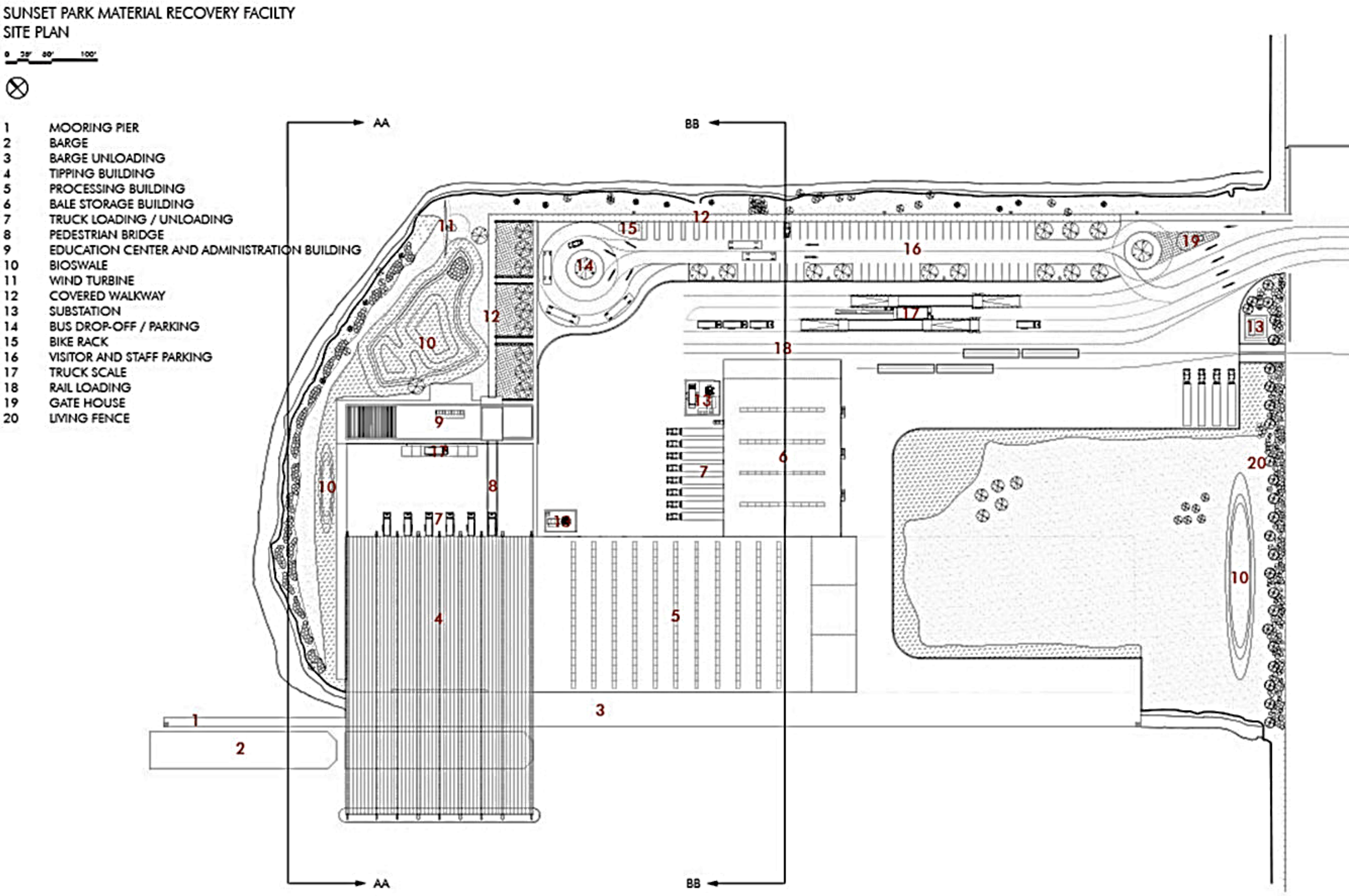


Figure 67: Master plan of Sunset Park MRF

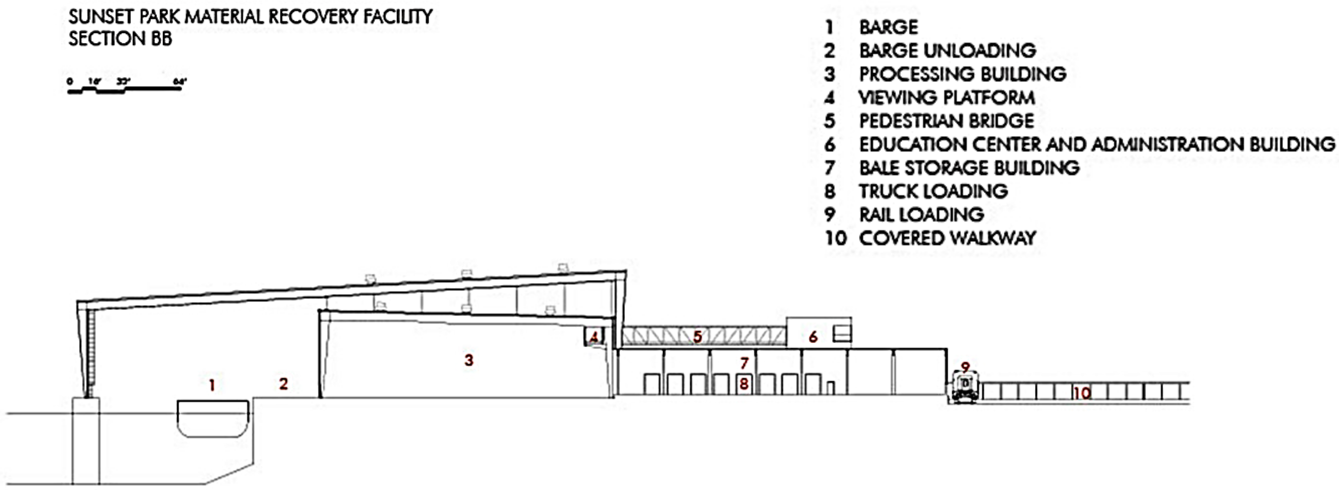


Figure 66: Longitudinal Section through B-B
Source: (*Sunset Park Material Recovery Facility / Selldorf Architects | Arch Daily*)

1. Tipping building:

It is the area where materials arrive by barge or truck. It is dumped into a pile on the main facility's floor where large items are removed manually and the rest put on conveyor belt. The tipping building's exterior is composed of exposed steel girders and lateral bracing; according to architectural writer Pavel Bendov, this helped the facility "avoid its fate as another box warehouse".

Figure 69: Barges, loading and unloading area

Figure 68: Waste collection inside tipping building

2. Processing building:

The processing building consists of about 2 miles (3.2 km) of conveyors in the plant. The conveyor line initially passes through a slow shredder with large gaps, which opens the bags carrying the materials. Specialized machines are used to collect certain materials from the stream, such as a spinning magnetic drum to extract tin cans. Another machine breaks up glass into small enough pieces to fall through a disc screen and into a dedicated stream below it. A drum magnet is used to extract ferrous metals from glass. Optical

Figure 70: View of conveyer belt from the deck that connect education center through bridge

Source: (*Sunset Park Material Recovery Facility / Selldorf Architects | Arch Daily*)

sorters recognize and separate different types of plastic and paper, with air jets moving selected objects from one line to the next. An eddy current separator removes most of the remaining metals before passing through a trammel at the end of the line. Human inspectors are primarily involved near the end of the process to correct any errors made by the machines. The separated materials are then collected, compressed into blocks, and transported away from the main facility, primarily by train. It takes between two and ten minutes for an object to be placed on the first conveyor belt and bundled at the other end.

3. The Education Center

The administrative building includes an education center for student and tour groups which includes exhibits explaining how the plant operates. Education center is one of the project's most unique features. The structure contains programs for school children and the public including classrooms, exhibitions, and interactive demonstration displays.

A key element of the design is a steel bridge which connects the Education Center to a viewing platform inside the Processing Facility. An elevated pedestrian walkway connects the administrative building to the main processing building for public viewing. The viewing platform allows students and visitors to see the recycling process in action.

Figure 72: Visitors entry for Education Center

Figure 71: Bride connecting Education Centre and Processing area

4. Building Material and Technology

Working within a pre-engineered building, one of the design challenges was to find ways to articulate the program and give an overall expression to the facility that would distinguish it from ordinary big box construction. In response, structural elements are inverted to appear on the exterior, giving steel girders and lateral bracing a greater visual impact.

Figure 73: Steel Girders and Lateral Bracing appears in exterior

The construction of building has utilized variety of recycled materials. The building is made almost entirely of recycled steel. Site fill is made from a composite of recycled glass, asphalt and rock reclaimed from the Second Avenue subway construction; metal buildings are 98% recycled steel; and visitor plazas are finished with recycled glass.

- **Environmental Quality**

The new recycling plant was built using sustainable materials. It makes extensive use of recyclable materials throughout its construction. Natural lighting and renewable energy production are included in the green design: On-site rainwater treatment includes water-efficient landscaping . Processing procedures are included to reduce the influence of dust, odors, or rubbish on the surrounding region. Other sustainable strategies include one of New York's largest photovoltaic applications of 600kW solar energy. In addition, the facility makes a significant environmental contribution by delivering recyclables by barge; this strategy reduces the distance collection trucks must travel and eliminates 240,000 miles of annual vehicle travel from roadways, ultimately contributing to the building's and the environment's sustainability.*(Sunset Park Material Recovery Facility / Selldorf Architects | ArchDaily)*

- **INFERENCES:**

• Waste and social activities can work together to enhance public awareness with the support of public enegement.
• The connection between the recycling area and the educational area is an essential aspect to consider. The circulation pattern must not interfere with the operation of any zone.
• The use of recycled materials in its construction may be appropriate environmentally sustainable methods.

3.2.2 SYDHVYNS RECYCLING CENTER:

- **INTRODUCTION:**
  - Location: Sydhavyns, Copenhagen, Denmark
  - Architects: Bjarke Ingles Group
  - Site area: Approx. 1500 sq. M
  - Project type: Community recycling center

Figure 74: Sydhavyns Recycling Center
Source: (*BIG Designs Danish Recycling Center as Neighborhood Asset | Arch Daily*)

- **PURPOSE OF STUDY:**
  - To study how to integrate parks and public amenities within recycling centers.
  - To learn how utilitarian industrial building can be designed

- **ABOUT:**

Bjarke Ingles Group designed the Sydhavyns Recycling Center, as **"a public location rather than a piece of infrastructure,"** with recycling facilities in the center and a grassy park on top. It is located southwest of Copenhagen's old city center in the Sydhavyns area. The recycling plant is embedded in the landscape (manmade hill). The idea of this design is to bury the building rather than separate it from its surroundings.

The man-made hill constructed as a public place that hosts a variety of activities throughout the year. The hill has picnic places, children's play areas, a jogging path, and a viewing platform from which visitors may learn about the recycling process at the center. This man-made hill may also be used for snowboarding throughout the winter, making it suitable for all seasons. The recycling center is in the shape of a submerged 8 and a pathway has been built around it so that users can see the recycling process directly. A tunnel-like opening at the north-east corner of the site will function as an entrance and exit for vehicles, allowing drivers to circumnavigate the entire space.

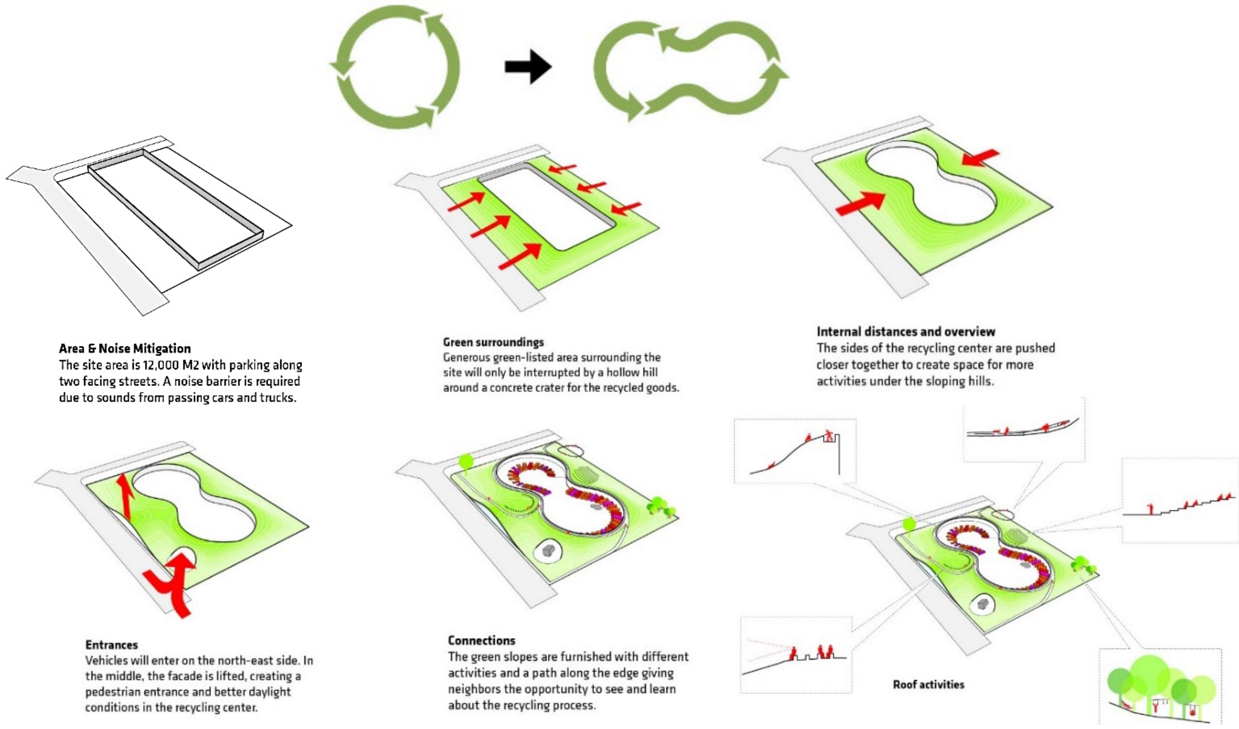


Figure 76: Design Approaches of Sydhavyns Recycling Center

Source: : (*BIG Designs Danish Recycling Center as Neighborhood Asset | Arch Daily*)

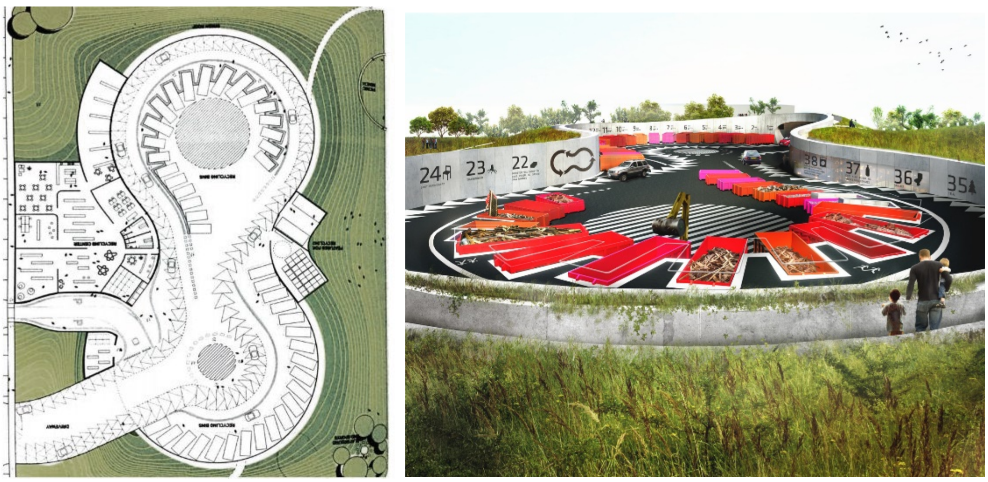


Figure 75: Master plan of Sydhavyns Recycling Center

Saptial Distribution:

Sydhavyns Recycling Centre Consists various collection points with educational infrastructures to investigate the possibility of different types of materials designed into urban landscape within manmade hill. The various spaces in this recycling centre are listed below:

- Collection bins
- Park
- Educational facilities
- Separate vehicular and pedestrian entry exit
- Second handshops

By integrating with public life and recycling centers, a person coming to this facility for a morning walk might see recycling operations in the center and be interested to learn more, thereby influencing and encouraging recycling habits in people.

The recycling center was built with recycled materials ranging from recycled concrete to recycled wood for viewing platforms. One of the principal collections in the recycling center is building materials from various sites, which are recycled as directed.

This integration of buildings and landscape in the urban environment represents a significant shift in design thinking. Given that all spaces, both buildings and landscapes, are constructed entities inside the city, frequently merging complex networks of infrastructure, it may be argued that any design must address the connection of architecture and landscape.

Figure 77: Recycling zone
Source: (Copenhagen)

INFERENCES:

- As a recycling center, various criteria need to be addressed from recycling to sustainability to educational and identifying the connections between these criteria is critical.
- Enclosed built form should be preferred for waste recycling so that it segregates people from ugly image of waste but still connects to spaces.
- New concepts should be introduced to people attract & engage people
- Design should make adequate consideration and Connection with surrounding environment
- Even if the function of public places varies according to season, design should be climate responsive and suitable for all seasons.

3.2.3 SHA TIN COMMUNITY GREEN STATION

➢ **INTRODUCTION:**

- Project type: Community recycling and education center
- Location: Hong Kong
- Architect: Hong Kong architectural service department
- Site area: 780 sq. m.

➢ **PURPOSE OF STUDY**

- To understand how a recycling center can provide awareness and education regarding waste management
- To study interconnection of various Public, semi private & private and Open, semi-open closed spaces:

Figure 78: Isometric View of Sha Tin Community Green Station
Source: .*("Community Green Station / ArchSD")*

➢ **ABOUT:**

It is a pilot project to implement the government's waste management strategy of "reduction first." The station promotes community recycling activities and holds exhibitions and educational programs to promote the importance of recycling. It includes an education center, a workshop, an office, and other facilities. The station was not intended to be a garbage collection site, but rather a beneficial addition to the neighborhood, transforming an underutilized parking lot into a gathering space designed with sustainable design techniques from their local culture.*("Community Green Station / ArchSD")*

Design concept:

The station is divided into two parts: the garden courtyard and the backcourt, which serve as exhibition and workshop spaces, respectively. The buildings are made up of modular containers that may be adjusted to suit the needs of various functions. The goal of the garden courtyard is to create a sense of community and an oasis in the center of an industrial neighborhood. As an interpretation of the pavilion concept in Chinese gardens, it generates many layers of space ranging from public to private, open to semi-open to enclose.

These 'pavilion' and ‘veranda' elements are reflected in the exhibition space and circulation area, with daylight diffused through bamboo screens and trellis. Open plan layout and connectivity between indoor and outdoor space allow for flexible space use. Although the Green Station is only temporary, it represents long-term cultural value by rediscovering our roots and finding parallels with existing green elements.

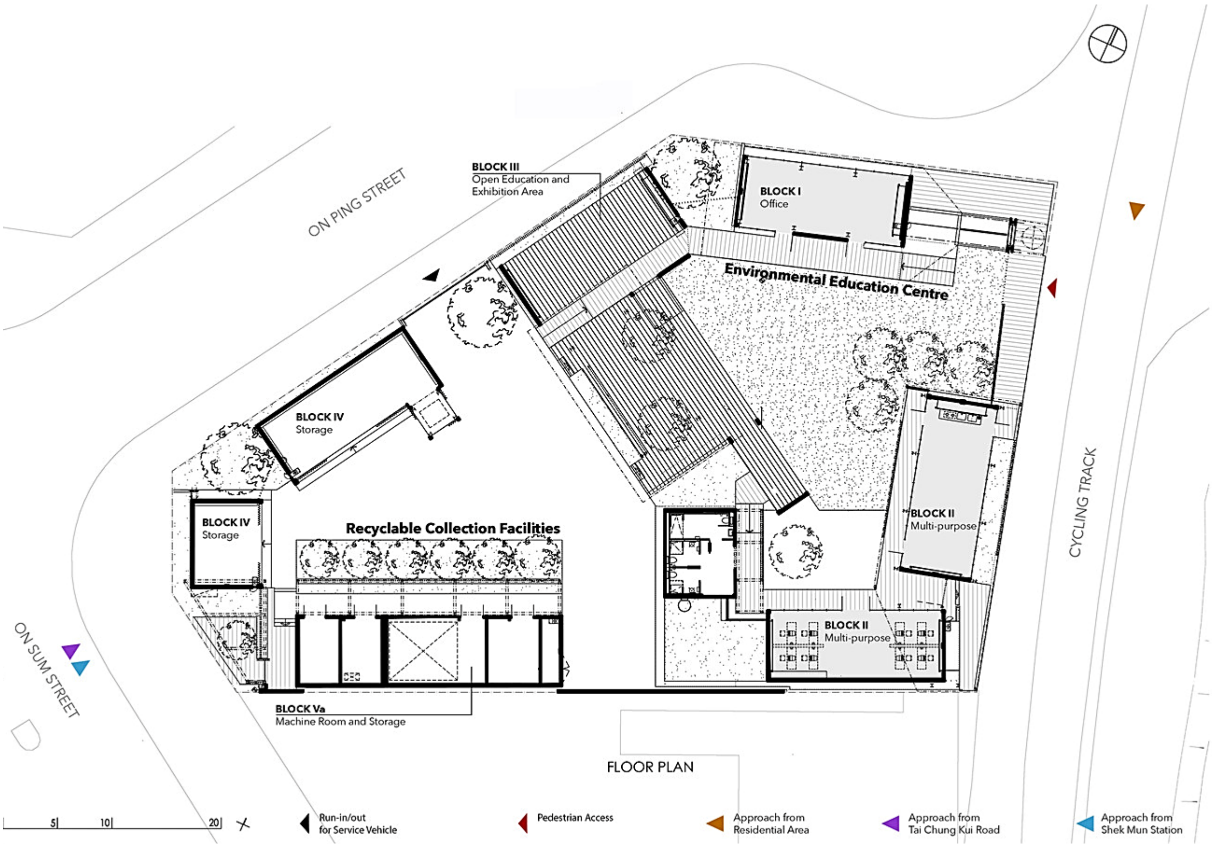


Figure 79: Master plan of Sha Tin Community Green Station

Source: *(“Community Green Station / ArchSD”)*

Spatial distribution:

This project has two major components: an educational aspect and a waste management aspect. They are divided into two zones while remaining connected to waste management and education. The following are the specific spaces at the community green station:

- Recycling station with storage and collection areas
- Machine room
- Education and exhibition area
- Office multipurpose are
- Garden area
- Open and semi open spaces for public hangouts

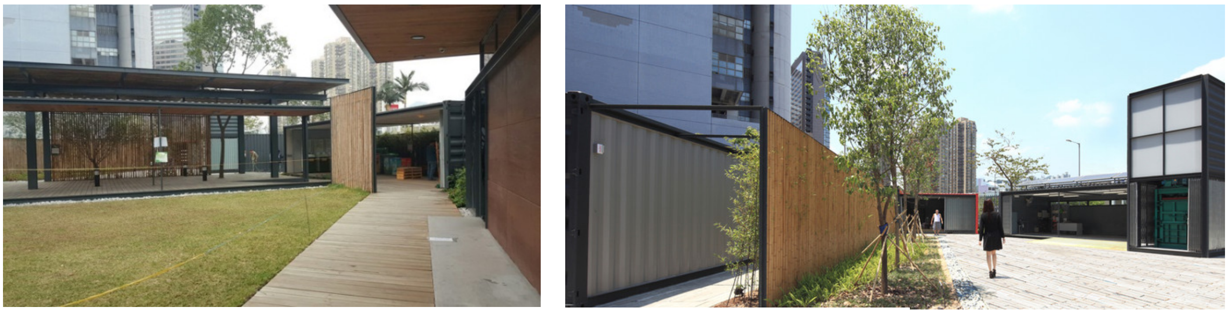


Figure 80: Garden Courtyard Spaces

Sustainability:

The building envelope opens to the courtyards to promote cross circulation, with a huge overhanging roof and vertical trellis/greening to provide shade from the sun. Large low-e glazing lets in natural light into the workplace and multi-purpose room. Through the bamboo ceiling and semi-enclosed wall, the exhibition room is well-lit.

Modular and off-site prefabricated building components greatly improve buildability. The containers, tiles, and paving blocks are all made from recycled or salvaged materials.

Figure 81: Waste reduction strategies

Source: ("Alla Community Green Station Di Sha Tin Essere Ecologici Aiuta a Rilassarsi")

- **INFERENCES:**

Many lessons can be acquired from Community Green Station and their attempts to create a greener society. Involving the public through beneficial spaces and facilities, combined with waste reduction techniques, has resulted in a significant positive impact in the community. The following are some of the study's major findings:

• Waste recycling centers in urban areas can be used for entertainment and education.

• Designing waste treatment facilities requires flexible areas and their link with proper zoning from open to closed and public to private.

• As people become more aware of the need of living a sustainable lifestyle and reducing waste, environments and architecture should reflect those values through passive and sustainable design techniques.

3.2.4 SHENZHEN EAST WASTE-TO-ENERGY PLANT

INTRODUCTION:

- Project type: Waste to energy plant
- Location: Shenzhen, China
- Architect: Schmidt Hammer Lassen Architects, Gottlieb Paludan Architects
- Site area: Approx.267,000 Sq. M

- **PURPOSE OF STUDY:**

- To study the built forms of waste treatment plants
- To learn about sustainable and energy efficient design approaches that can be integrated in built forms.

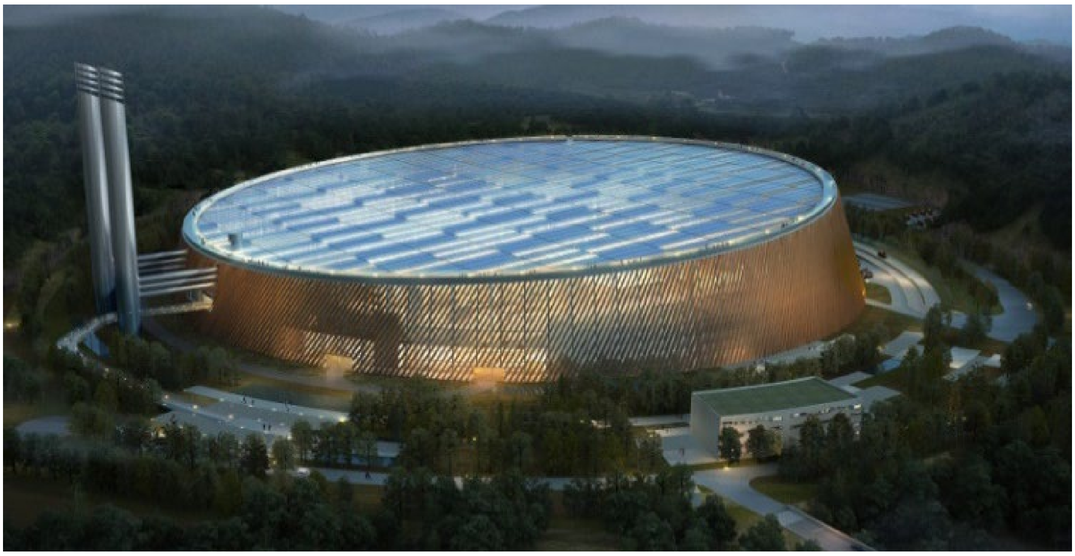


Figure 82: Shenzhen East Waste-to-Energy Plant
Source: ("Shenzhen East Waste-to-Energy Plant")

- **ABOUT:**

Located on the outskirts of Shenzhen, China, the Shenzhen East waste-to-energy project is a **165MW** power plant under construction. It will be one of the world's largest waste-to-energy (WTE) plants, upon completion. It will be capable of combusting **5,600 tons** (t) of municipal solid waste a day. The plant will be capable of processing roughly one-third of the annual municipal solid waste generated in Shenzhen and produce **550 million kWh of electricity a year.**

The project firstly aim is to provide a clean, simple, and modern technical facility to deal with the city's growing waste. At same time it aims to educate visitors about the city's growing waste problem by taking them on an elevated walkway tour of the plant, which concludes with a 1.5-kilometer panoramic view of both the surrounding mountains and the 66,000-square-metre roofscape, which will be geared to producing actual renewable energy.*(World's Largest Waste-to-Energy Plant Set to Open Next Year in Shenzhen | ArchDaily)*

Architecture:

The challenges for designing this waste to energy plant was:

- Developing a unifying architectural concept for a very large and complex technical facility in a sensitive environment.
- Integrating heavy technical infrastructure with public access and education facilities.*("Shenzhen, China - Waste-to-Energy Plant")*

Danish firms Schmidt Hammer Lassen Architects and Gottlieb Paludan Architects proposed the facility will utilize the most advanced technology in waste incineration and power generation and that will also feature a series of visitor facilities, including a looping leading up to a rooftop viewing platform. The entrance will be a snaking ramp that starts from a landscaped park and winds up between a pair of smokestacks.

Figure 83: Exterior view of Shenzhen East Waste-to-Energy Plant with smoke stacks

The plant is designed as a compact circular building envelope that will be integrated into a landscape park. The building features a circular form to control the footprint of the structure and the amount of excavation required to build on the site. The scheme organizes the entire plant, office spaces, visitor amenities, display zones, and other ancillary structures, into one structure - breaking with the traditional rectangular layout of industrial facilities.

The roof structure is a large-scale truss system with 60-meter maximum spans and a 4-meter structural height. Photovoltaic panels span 44,000 square meters, or almost two-thirds of the entire roof area, giving the facility the opportunity to not only provide a cleaner manner to deal with the city's garbage but also contribute to the city's renewable energy provision and to create its own sustainable energy source.

The plant's sloped surrounding façade structure is made up of truss girders ranging in length from 30 to 50 meters. The girders span from the upper ring girder to the lower support points, creating a minimal substructure for the facade cladding. Additional T-beams connect the façade lamellas to the substructure.

A looping walkway invites visitors to take a tour around offering a glimpse behind the scenes of the plant machinery, before it leads up to a rooftop viewing platform overlooking the surrounding landscape. *("Shenzhen East Waste-to-Energy Plant")*

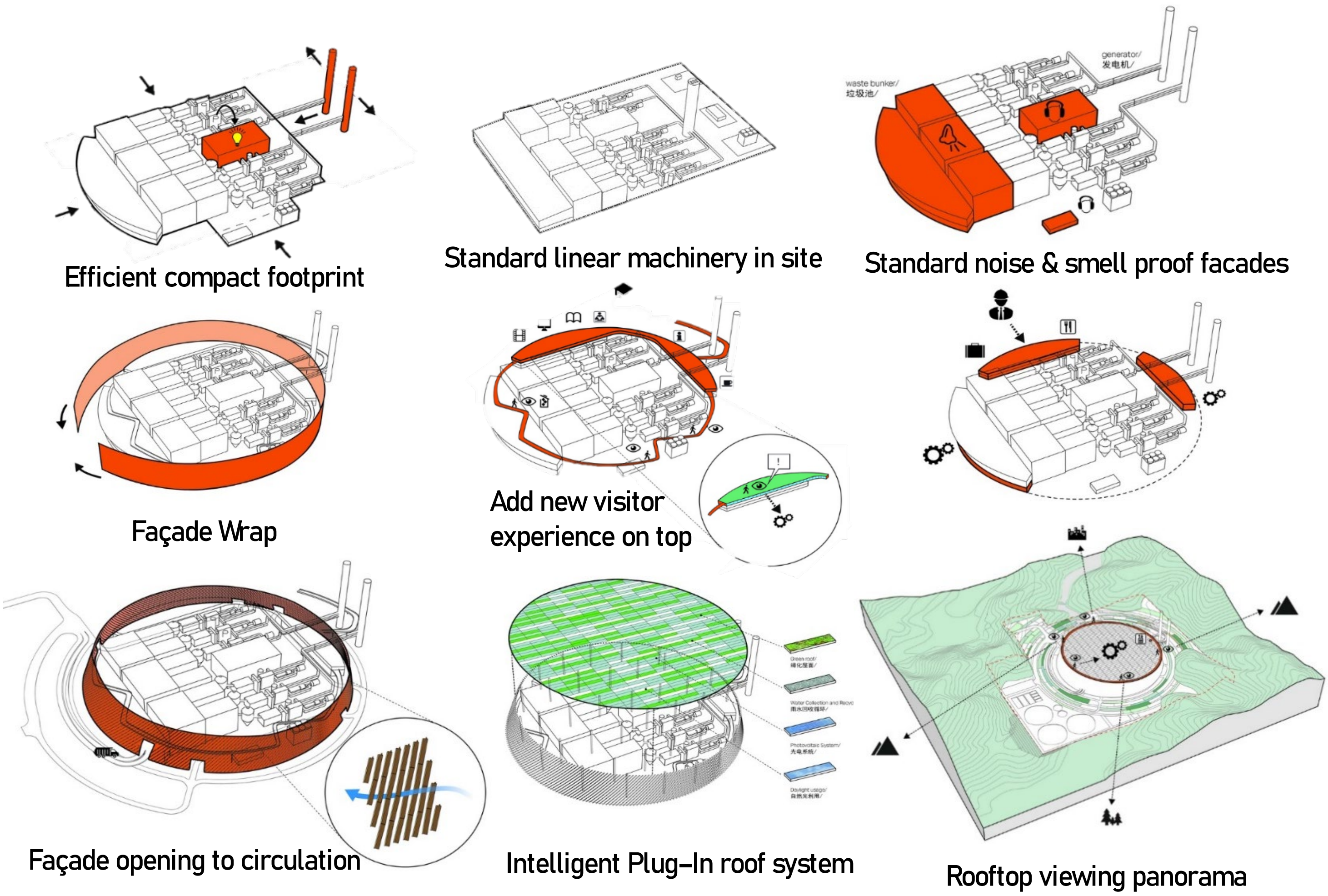


Figure 84: Process of Form Development
Source: *(World's Largest Waste-to-Energy Plant Set to Open Next Year in Shenzhen | ArchDaily)*

- **INFERENCES:**

• The project's-built form must be capable of integrating sustainable and energy-efficient solutions.

• During the design phase, both technical and architectural concerns must be equally prioritized.

• While designing such a waste management facility, it must be ensured that the project has as little impact on the environment as possible.

• Investing in green alternatives will benefit both people and the environment in the long term.

• Waste education and recreational activities can be effectively integrated, and innovative design concepts can be implemented.

3.3 Comparison between inferences from national and international case studies:

- Each project in the **international case studies** process on active public engagement in waste, promoting recreational and learning activities.
- All of the projects have been architecturally and technically designed.
- Functions are zoned across the facility based on program requirements and the desired user's circulation pattern for effective interaction with different user groups.
- On top, spaces such as the café and organic farm guide visitors through all functions, raising awareness. Users are being educated through architectural expression.
- To ensure uninterrupted service, separate vehicular and pedestrian circulation is encouraged across the facility.
- Waste management facilities are intended to serve the project and its nearby surroundings. This creates a module that may be strategically repeated throughout a city, with each module offering services within a specified radius of development.
- The establishment of a service-oriented function alongside a public function is a major concept used in all international case studies.

In contrary to international case studies, **national case studies** lack of engagement of architecture and design in Nepal's waste management facility and recycling units. The built environment that houses waste management processes is frequently hidden from public view. People also believed that industrial buildings would or should always be unsightly. Waste management facilities are frequently hidden away in industrial parts of a city that are easily ignored.

As a result, the interrelationship between public activities and waste observed in international case studies must be adopted in waste management facilities in Nepal as well. Thus, this thesis attempts to apply innovative design inferences from international case studies to design a waste recycling facility for Kathmandu metropolitan city that breaks the notion of waste recycling facility-built structure as ugly by integrating waste infrastructure with public life to create a sustainable waste management system.

4. SITE ANALYSIS:

4.1 SITE SELECTION:

The proposed site for the thesis project,” Waste recycling center” for Kathmandu Metropolitan City is located at **Teku, Kathmandu**. It is the current site of Teku transfer station.

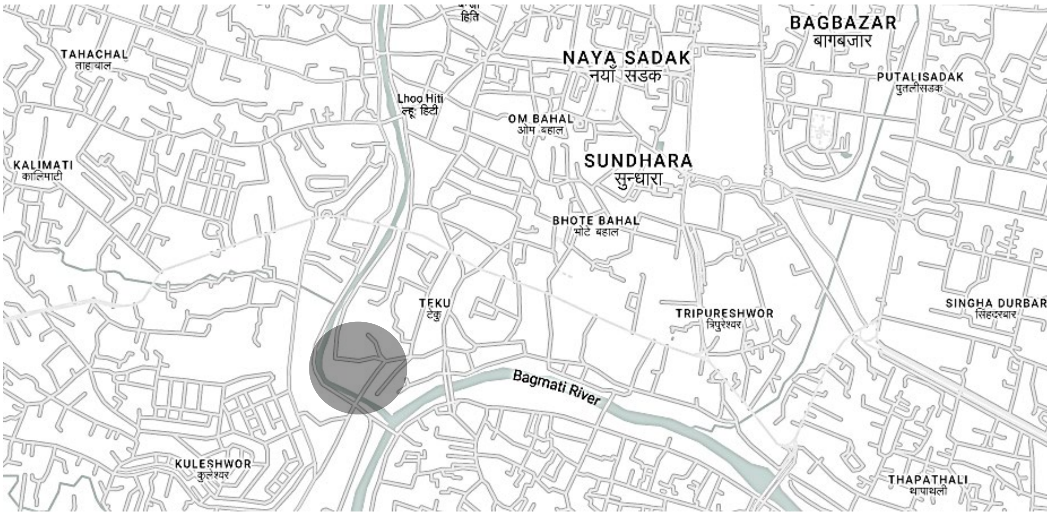


Figure 85: Site Location of Proposed Site

KATHMANDU METROPOLITAN CITY MAP

TEKU, KATHMANDU

PROPOSED SITE

4.2 SITE JUSTIFICATION:

The KMC operated a transfer station in Teku, which was built as an integrated waste management facility with sustainability as a center for waste collection from all across Kathmandu. Originally, the transfer center included infrastructure for segregating various wastes and composting organic waste. It includes compost plant, vermicomposting stations, and a bio gas plant for more sustainable waste management.

However, it has been observed that these infrastructures are now underutilized due to managerial issues. KMC is unable to improve waste processing efficiency or gain revenue from the use of waste resources due to a lack of developed infrastructure, resulting in negative impact on the environment. Furthermore, residents in the area have complained about a range of health difficulties.

As a solution, KMC should continue to operate the current waste separation and composting infrastructure in accordance with environmental rules. At the transfer point, waste segregation and recycling resources should be available. The station should be transformed from an open to a closed transfer facility by constructing the necessary infrastructure, and adequate precautions should be made to reduce foul odor and leachate discharge.

Thus, for the very thesis project 'Waste Recycling Center' for Kathmandu Metropolitan City, it is thought to rethink site of Teku Transfer Station as proposed site as it caters following criteria:

- Collection point of waste of KMC.
- Have vehicular accessibility
- Located on the center of city-can encourage public engagement
- Potential of rejuvenation of site by eco-friendly approach
- Consists of some waste management plants

4.3 SITE INFORMATION:

- **Location** : **Teku, Kathmandu Metropolitan City**
- **Total site area** : **19398 sq. m (Approx. 39 ropanis)**
- **Topography** : **Almost flat**
- **Ownership** : **Teku Transfer Station (Government Property)**
- **Latitude:** : **27°41'35.95"N**
- **Longitude** : **85°18'3.09"E**

Figure 86: Proposed site area

Figure 87: Change of Teku Transfer Station in 10 years

SITE ATTRIBUTES:

ROAD NETWORK

URBAN CONTEXT

NATURAL FEATURE

- **Surrounding:**
  - East : Kawadi Recyclers (Temporary Structures)
  - West : Bishnumati River and Residence Area
  - North : Residential area
  - South : Bishnumati River Teku Dovan

- **Accessibility:**

  The proposed site is easily accessible from 3 sides. It is linked by black topped vehicular roads. One from western side connecting to Kalimati. One from northeast side connecting to Sanepa and one from south connecting to Kuleshwor.

- **Natural factors:**
  - Topography: The site is almost flat.
  - Vegetation: Since this site is a transfer station, there is very little vegetation on the western side of the site, which was a garden area years ago.
  - Hydrology: There is Bishnumati River flowing on the western side of the site and Bagmati River near the site.
  - Climate: The climate here is mild, and generally warm and temperate, the average annual temperature is 16.1 °C.

The month with the highest relative humidity (92.36%) is July. The month with the lowest relative humidity (54.28%) is April. Summers in Kathmandu are rainier than winters. The month with the rainiest days is July and the month with the least rainy days is December.

In April, Kathmandu has the largest number of daily hours of sunshine on average that is an average of 9.95 hours of sunshine per day. On average, the number of daily hours of sunshine in Kathmandu is lowest in January that is an average of 4.27 hours of sunshine every day.

- Wind: Over the course of the year, the average hourly wind speed in Kathmandu shows mild seasonal change.

From February to July, the windier season lasts 5 months, with average wind speeds of more than 5.0 miles per hour. April is the windiest month in Kathmandu, with an average hourly wind speed of 6.2 miles/hour. The calmer season lasts 7 months, from July to February 15. December is the calmest month in Kathmandu, with an average hourly wind speed of 3.8/ hour.

The wind is most often from the *west* for *3.1 months*, from *March* to *April*. The wind is most often from the *south* for *5.7 months*, from *April* to *October.* The wind is most often from the *north* for *5.6 months*, from *October* to *March.*

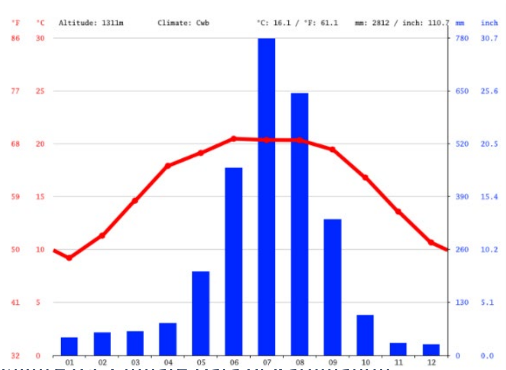


Figure 89: Climate Data of Kathmandu

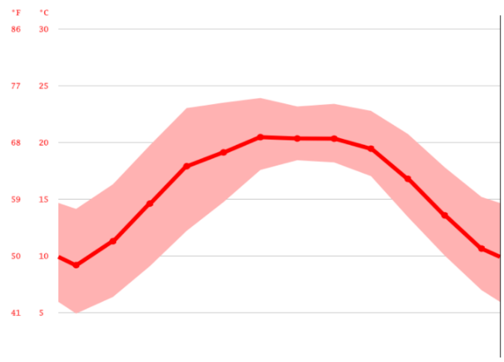


Figure 92: Average Temperature of Kathmandu

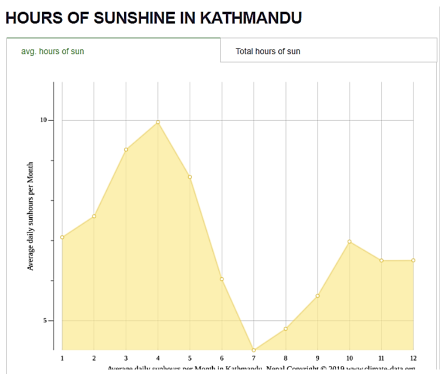


Figure 91: Sunshine hour in Kathmandu

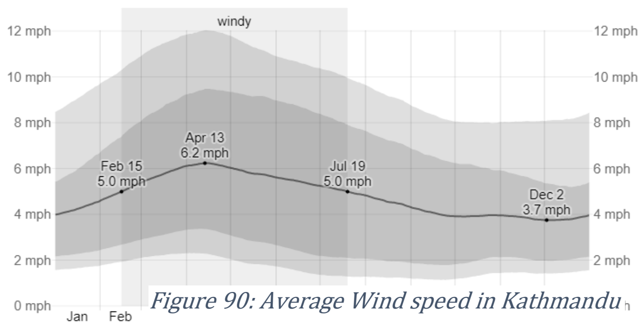
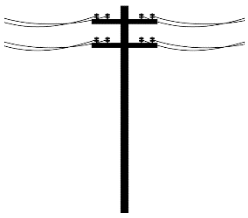


Figure 90: Average Wind speed in Kathmandu

Source: (*Kathmandu Climate: Average Temperature, Weather by Month, Kathmandu Weather Averages - Climate-Data.Org*)

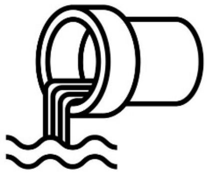
- **Infrastructures:**
  Major infrastructures available in in the site and their proximity are as listed below:

- Road



- Electricity

- Water facilities



- Sewerage

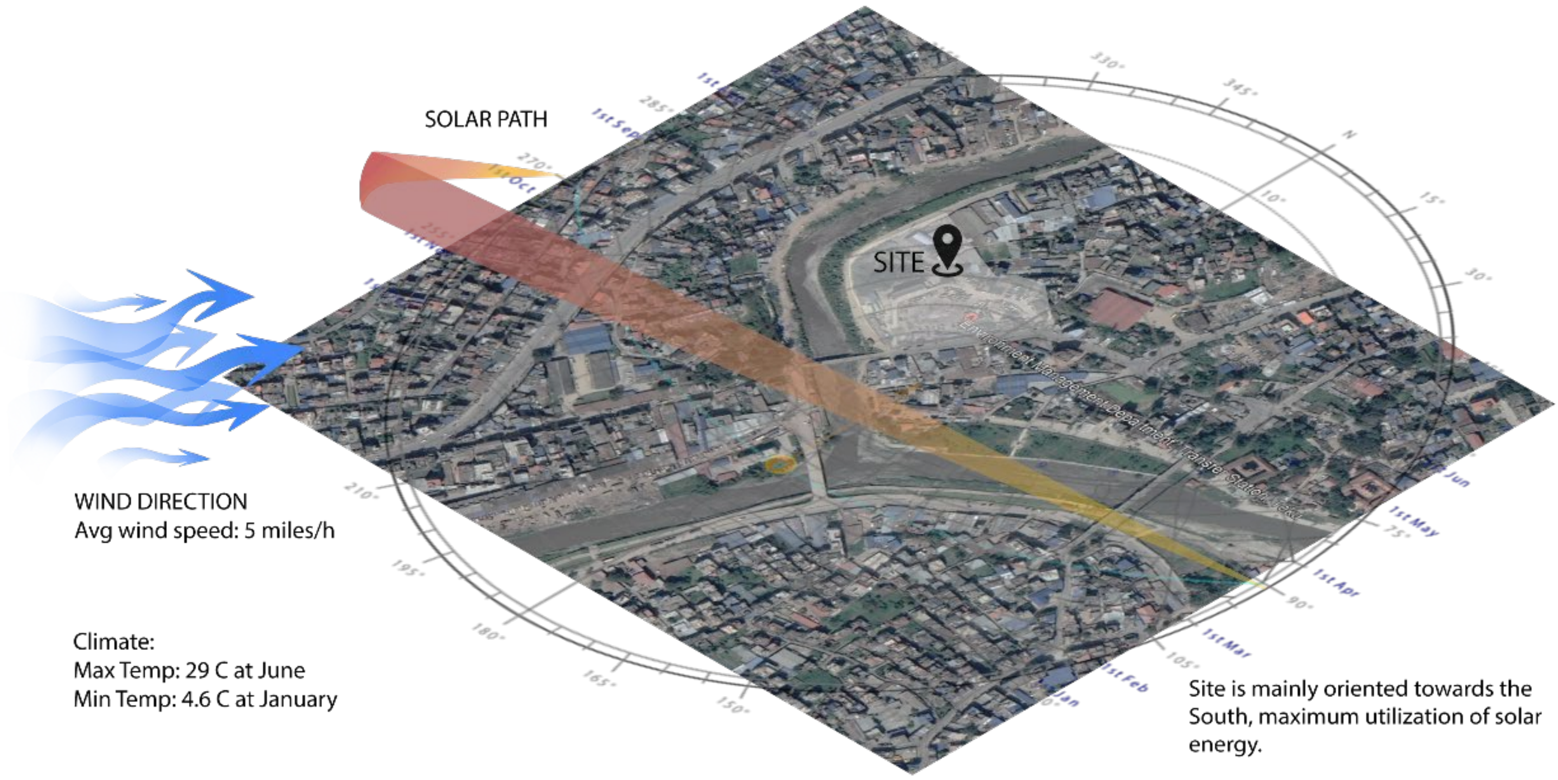


Figure 93: Site plan with Sun path & Wind Direction

4.4 Existing site conditions:

Figure 97: Vehicular Access Roads

Figure 94: Site Entrance Area

Figure 96: Site Area

Figure 95: Abandoned resources

4.5 SWOT ANALYSIS:

Strengths:

- Site location is collection point of waste
- Have vehicular accessibility from 3 sides
- Most of the infrastructures are available.

Weakness:

- Presence of many temporary structures.
- Available infrastructures not properly used..

Oppourtunities

- Potential of rejuvenation of site by eco-friendly approach.
- Being in accessible distance from settlements, open space and educational facilities can positively impact the communities nearby.

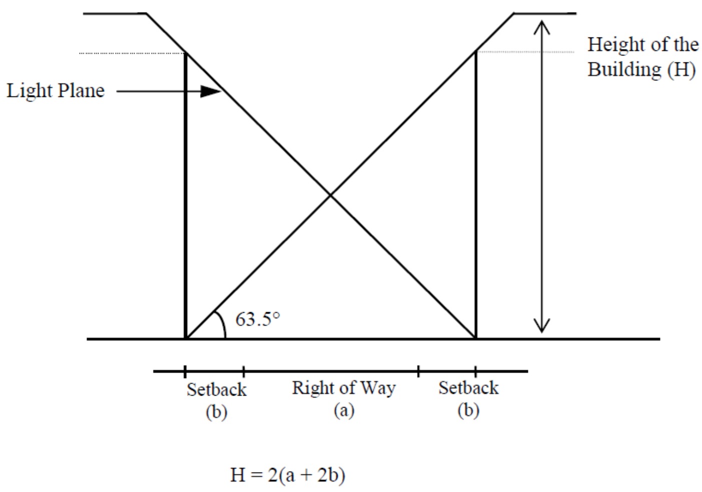
Threats:

- If not properly planned and designed,
  - Can cause adverse effect in environment
  - Cause pollution to Bishnumati River.

4.6 Bye laws:

Since, the building is designed as a public design:

- GCR:40%
- FAR: 2.5
- ROW:
- SETBACK:
  - minimum setback from the adjoining plot must be 3 m
  - 13-15m should be provided for the driveway and parking stalls
  - Setback from river -20 m



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4.7 Riverfront Development:

Riverfront development refers to development in front of water body. It is the zone of interaction between urban development and the water. It can be used as an additional buffer, creating a non-residential zone between the river and the built structures around it. Riverfront can be developed as meaningful socio interactive space, which can be plus point for the project.

Principles for riverfront development:

When planning a riverfront development, following core principles need to be thought upon:

- Feature the riverfront as the front door.
- Showcase the river's history.
- Limit obstacles and connect to the river.
- Engage with the water.
- Connect seamlessly along the riverfront and into neighborhoods.
- Repair and enhance the environment.
- Employ high-quality architectural materials and sustainable engineering practices.

(A Guide to Riverfront Development : Connecting communities to the water)

A Project on Integrated Development of the Bishnumati River Corridor and Historic Core in Kathmandu:

The Physical Development and Construction Department of Kathmandu Metropolitan City proposed the project to develop the Bishnumati River Corridor. The Bishnumati river corridor is a vital connector between Kathmandu and its surrounding municipalities. The river corridor is 2.8 kilometers long, stretching from Balaju in the north to Teku Bridge in the south. The following are the recommended activities, as per the report prepared by Devendra Dongol, Department Head:

- Construction of 4 lane road along river banks (completed in 2011)
- Improvement of Junctions and construction of pedestrian bridges-ongoing
- Greenery, Parks and Recreational facilities along River Banks-ongoing
- Construction of waste treatment facilities at various locations (proposed)
- Construction of parking facilities and the promotion and conservation of open spaces along the river banks - ongoing

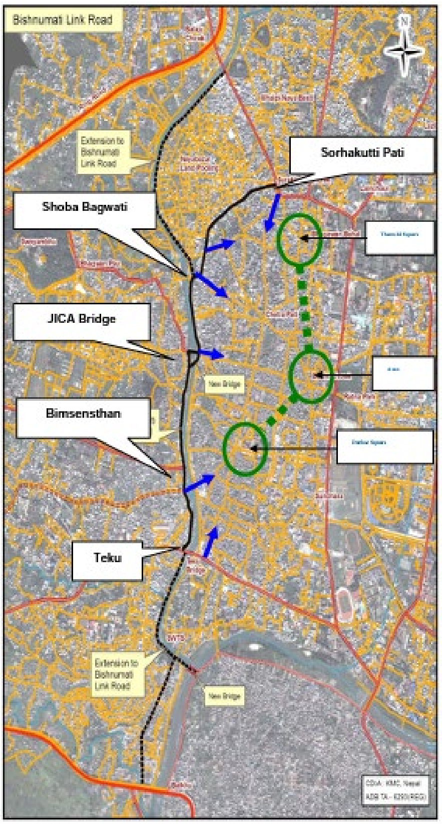


Figure 98: Bishnumati Corridor

5. PROGRAM FORMULATION:

Program formulation is done on the basis of literature review, case studies, site survey, site analysis and existing site conditions. Program formulation for the design of Waste Recycling Center is based on the area requirement of following three major components:

- **Waste facilities**
- **Employee's facilities**
- **Public amenities.**

5.1 Waste facilities:

The calculation of area requirement of the waste facilities depends upon the volume of waste generated/collected in Kathmandu Metropolitan City, its character and composition.

- Total MSW generation of KMC: 600 tons/day

Due to the constraints of site area, only 300 tons of waste can be catered by the designed waste recycling facility. Thus,

- Total MSW collected for transfer station: approx. 300 tons/day

With the assumption that Organic and inorganic waste are segregated at collection point, total organic and inorganic waste collected is:

- Composition of MSW:
  - Organic:51%=153 tons/day
  - Inorganic: 49%=147 tons/day
- With consideration of following, the program has been formulated:
  -

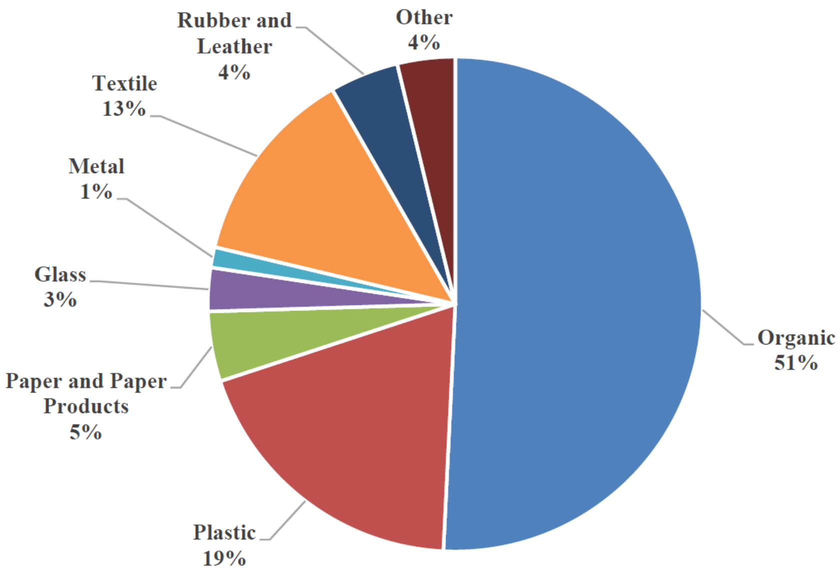


Figure 99: Waste composition of KMC

Table 1: Program Formulation

S. N	FUNCTIONS		AREA	REMARKS
1.	**TIPPING HALL**		**400 m^2**	
2.	**WASTE BUNKERS**	• Organic waste	250 m^2	1 ton=1.133m^3 Height: 4 m To accommodate waste of 4 days
		• Inorganic Waste	150 m^2	To accommodate waste of 2 days
• **TOTAL AREA:**			**400 m^2**	
3.	**MATERAL RECOVERY FACILITY**	• Receiving area	100 m^2	
		• Sorting /processing area	1100 m^2	
	• **TOTAL AREA:**		**1200 m^2**	
4.	**STORAGE (recyclables)**	• Plastic	80 m^2	19%=95 tons/day
		• Paper	30 m^2	5%=25 tons/day
		• Metal	20 m^2	2%=10 tons/day
		• Glass	30m^2	3%=15 tons/day
		• Residues	40 m^2	16%=80 tons/day
• **TOTAL AREA:**			**200 m^2**	
5.	**PLASTIC RECYCLING UNIT**	• Collection & sorting area	40 m^2	
		• Flex manufacturing area	300 m^2	
		• Pellet manufacturing area	350 m^2	
		• Product storage	50 m^2	
		• Control room	40 m^2	
• **TOTAL AREA:**			**800 m^2**	
6.	**PAPER RECYCLING UNIT**	Collection & sorting area	35 m^2	
		Processing area	500 m^2	
		Final product storage	50 m^2	

		Control room	35 m^2	
• **TOTAL AREA:**			**630 m^2**	
7.	**ANAEROBIC DIGESTOR**			• 4 Cylindrical tanks with radius:7m and height: 8m (Biogas Production takes about 20 days) • Each digester can accommodate organic waste of 5 days
		• Digester tank	800 m^2	
		• Gas Storage	100 m^2	
		• Digestate Storage	150 m^2	
• **TOTAL AREA:**			**1000 m^2**	

TOTAL AREA FOR WASTE FACILITIES: 4600 m^2

5.2 Employee Facilities:

The calculation of area requirement for employee's facilities is done on the basis of facility provided and no. of staffs.

Considering total employees to be 100, with male: female ratio 60:40, the program has been formulated.

Note: the no. of employees is flexible and changes as per requirement in design.

S. N	FUNCTIONS		AREA	REMARKS
1.	**ADMINISTRATION**	• Reception & waiting area	30 m^2	
		• Admin/Office	60 m^2	Separate office: 8-10m^2 For 5 executive members& 5 staffs
		• Meeting Room	20 m^2	
		• Staff Room	75 m^2	
		• Supervisor Room	10 m^2	
		• Store	10 m^2	
		○ **TOTAL AREA:**	**300 m^2**	
2.	**CHANGING & LOCKER ROOM**	• Male	30 m^2	
		• Female	15 m^2	
		○ **TOTAL AREA:**	**50 m^2**	
3.	**WASHING FACILITIES**	• Shower room	30 m^2	

		• Washrooms & basins	25 m^2	
		○ **TOTAL AREA:**	**60 m^2**	
4.	**TOILET FACILITIES**	• Male	20 m^2	1 W/C, 1 washbasin, 1 urinal per 20-45 users
		• Female	15 m^2	1 W/C per 7-10 users, 1 wash basin per 40 users
• **TOTAL AREA**			**35 m^2**	
5.	**CAFETERIA**	• Dining room	300 m^2	
		• Kitchen	100 m^2	
		• Store	70 m^2	
• **TOTAL AREA**			**450 m^2**	
6.	**DISINFECTANT ROOM**		**15 m^2**	
7.	**FIRST AID ROOM**		**15 m^2**	
8.	**TRAINING CENTER**		**300 m^2**	
9.	**PARKING**			

TOTAL AREA FOR EMPLOYEE'S FACILITIES: 1100 m^2

5.3 Public Amenities

S. N	**FUNCTIONS**		**AREA**	**REMARKS**
1.	**PARKING**			Open space
2.	**EDUCATION CENTER**	• Classrooms	**120m^2**	2 for 32 persons each
		• Conference hall	**450 m^2**	For 250 persons
		• Recycling workshop studio	**400 m^2**	2 for 40 person each
		• **TOTAL AREA**	**1200 m^2**	
3.	**EXHIBITION HALL**		**400 m^2**	
4.	**RESTAURANT**		**500 m^2**	
5.	**RECYCLE PAVILLION**			Open space
6.	**COMMUNITY PARK**			Open Space
7.	**TOILET FACILITIES**			As per requirement

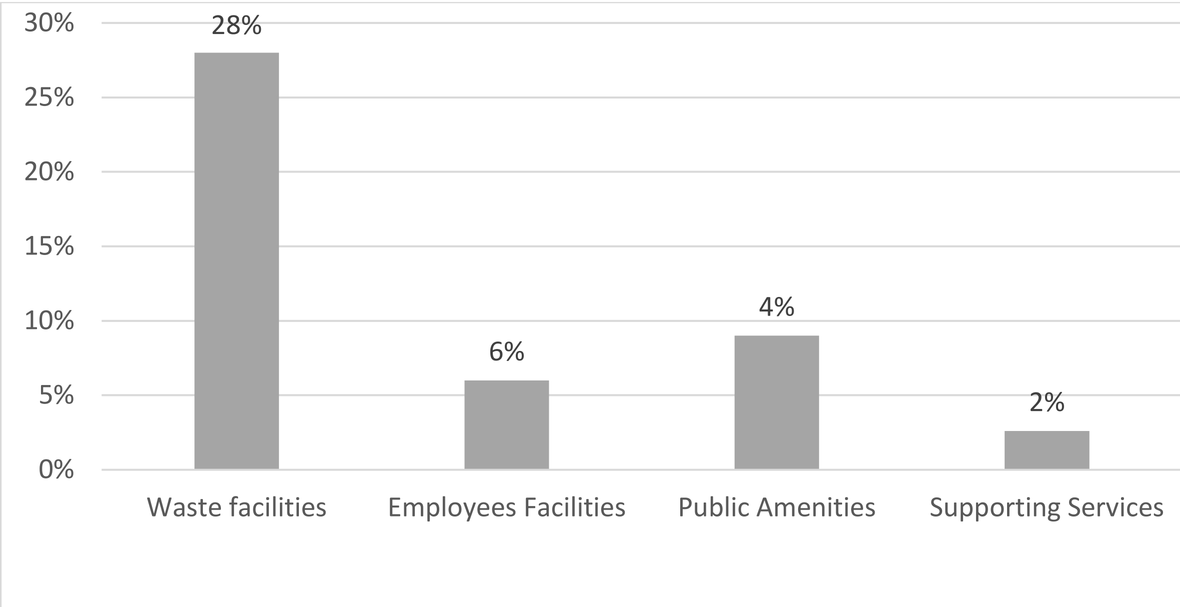
TOTAL AREA FOR PUBLIC AMENITIES: 2000m^2

5.4 Other Supporting Facilities

S. N	FUNCTIONS		AREA	REMARKS
1.	**GUARD HOUSE**		**100 m^2**	
2.	**SECURITY AND CONTROL ROOM**		**100 m^2**	
3.	**ELECTRICAL ROOM**		**150m^2**	
4.	**EQUIPMENT ROOM**		**150m^2**	

TOTAL AREA FOR PUBLIC AMENITIES: 500 m^2

- **Total built up area:8500m^2**



In designed building

- **Total built up area:9900m^2**
- **Total Ground floor area:6022 m^2**
- **Total ground coverage :32%**

6. CONCEPT AND DESIGN DEVELOPMENT

Waste is a byproduct of daily life that represents the end of a material's life cycle. The concept of recycling creates a new life from this end, allowing the life process to continue. As a result, the concept of **REBIRTH** can be said to represent the main theme of this recycling project.

6.1 DESIGN CONCEPT

Before getting into the concept, the cloud word with the keywords that defined the essence of project was formed, which provided the guideline to derive the core concept for the design of the project.

"LOTUS BLOOMS IN THE MUD"

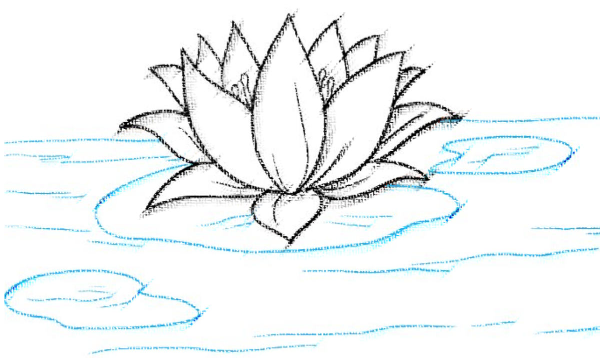


Figure 100: Concept: Lotus blooms in the mud

The lotus resembles the juxtaposition of something pure and beautiful that grows from a muddy and untouched pond. Even the most beautiful flower – the lotus- rises from the dark muddy water symbolizing, there is always **a ray of hope**, that we can bring good out of the bad. It symbolizes that out of ugliness and destruction also we can create something beautiful and pleasant, which is relevant in context of project-Waste Recycling center that we can create something beautiful out of waste too.

Also, Re-birth is deeply symbolized by the flower –**lotus**. With its roots attached in mud, Lotus submerges every night into water and re-blooms the next morning. Even with its daily process, it symbolizes life, death and reemergence. This concept totally aligns with the major theme of project: **"RE-BIRTH"** which also means to bring unused materials back to life (use).

Thus, the mud signifies waste, and the blooming of the lotus signifies the hope for **positive change** that the project-the waste recycling center-can bring to the environment and society. Also, a lotus blooms one petal at a time, which can be interpreted as the project's initial gradual progress toward future prospects.

Architectural Analysis:

Lotus has always been an inspiration to architecture, whether because of its religious features or beliefs, or because of the bio mimic approach. Even, in ancient times, Egyptians imitated the lotus flower in architecture and used it in decorative decoration of walls and ceilings. Also, the lotus flower has always been considered a symbol of purity in both Hinduism and Buddhism, providing it a greater value in architecture of both cultures.

Upon its architectural analysis, the lotus flower has a special surface that repels dust and dirt, allowing its petals to shine. It has an efficient mechanism for collecting rainwater in its leaves. It allows water to flow through its leaves, keeping it clean and healthy.

Thus, we can mimic how the lotus flower regulates light, nutrition, and self-shading. As a result, we can suggest sustainable approaches for the project, which, as a waste recycling center, must ensure energy efficiency and sustainability. Thus, we can have a design that

- can effectively collect rainwater
- has optimal natural lighting conditions
- has self-shading/screening

Also, the lotus flower's ability to repel dust and dirt aligns with the concept of designing a waste recycling center that protects the environment and society from the negative impact of waste.

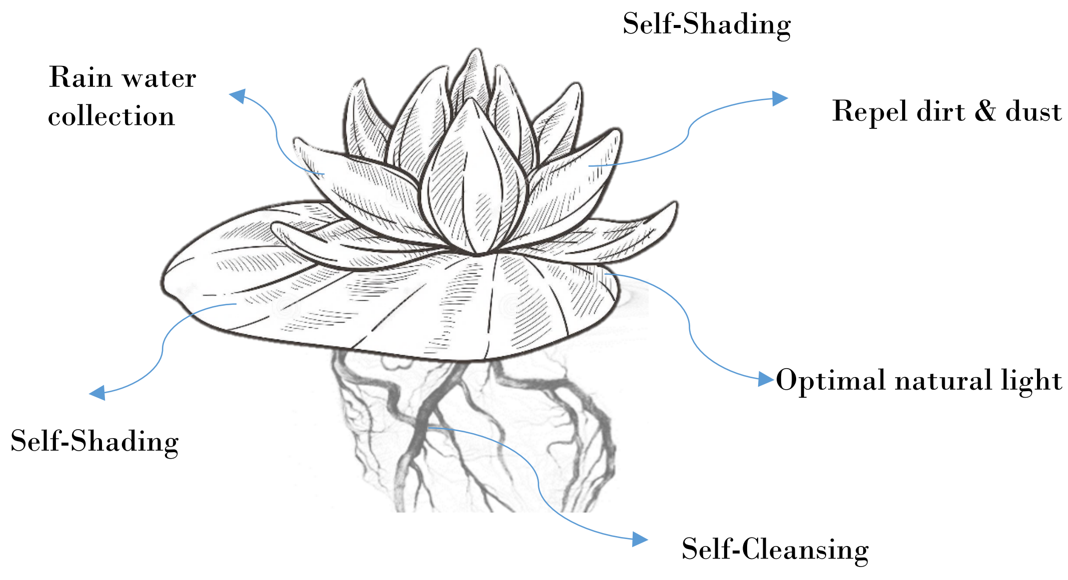
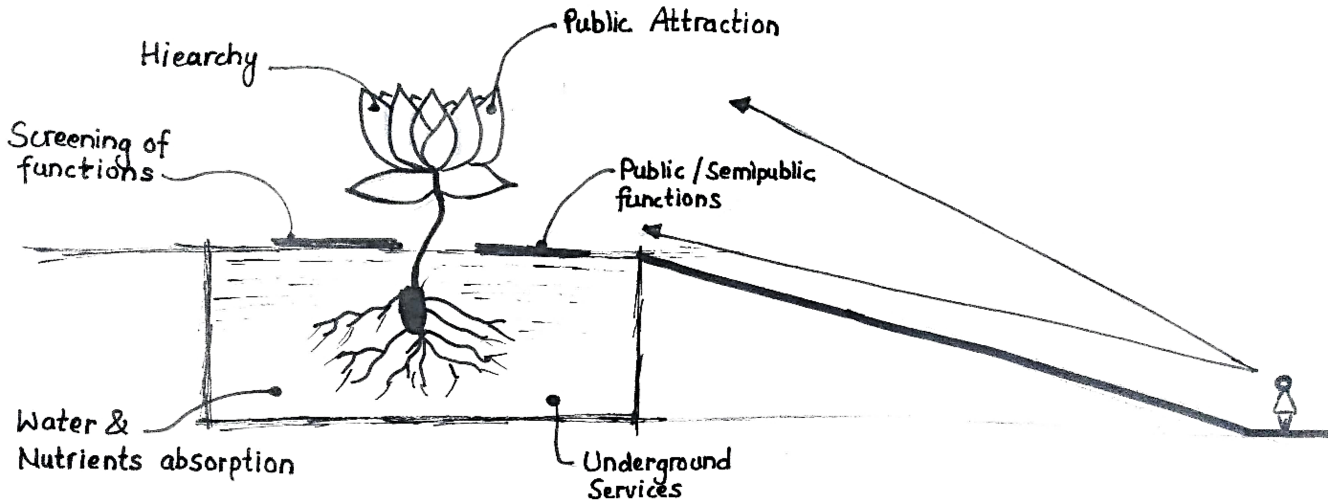


Figure 101: Architectural analysis of the Lotus flower

6.1.1 DERIVATION OF DESIGN IDEA FROM CONCEPT



The primary cleansing function of lotus flower is performed by the root, which is underground and attached to the mud. The large, broad leaves then hide the overall functional part, leaving the flower as the main attraction for the public. As a result, the strategy can be applied to the design.

The functional part of the waste recycling center, where the major process of recycling occurs, is represented as root, which is underground. This is then screened off from direct view of the public by the leaves, so that the public is only drawn to the public space as attracted by the flower. To give the industrial part an underground feel in relation to the public, the public is directly ascended to the industrial part's roof via the landscape.

As a result, it brings out the design, which provides a recycling facility within the semibasement enclosed built space and public space above it, which aligns with the project's goal of creating a recycling facility not only as infrastructure but also as a place for public engagement, while not directly exposing the public to the negative impacts of waste.

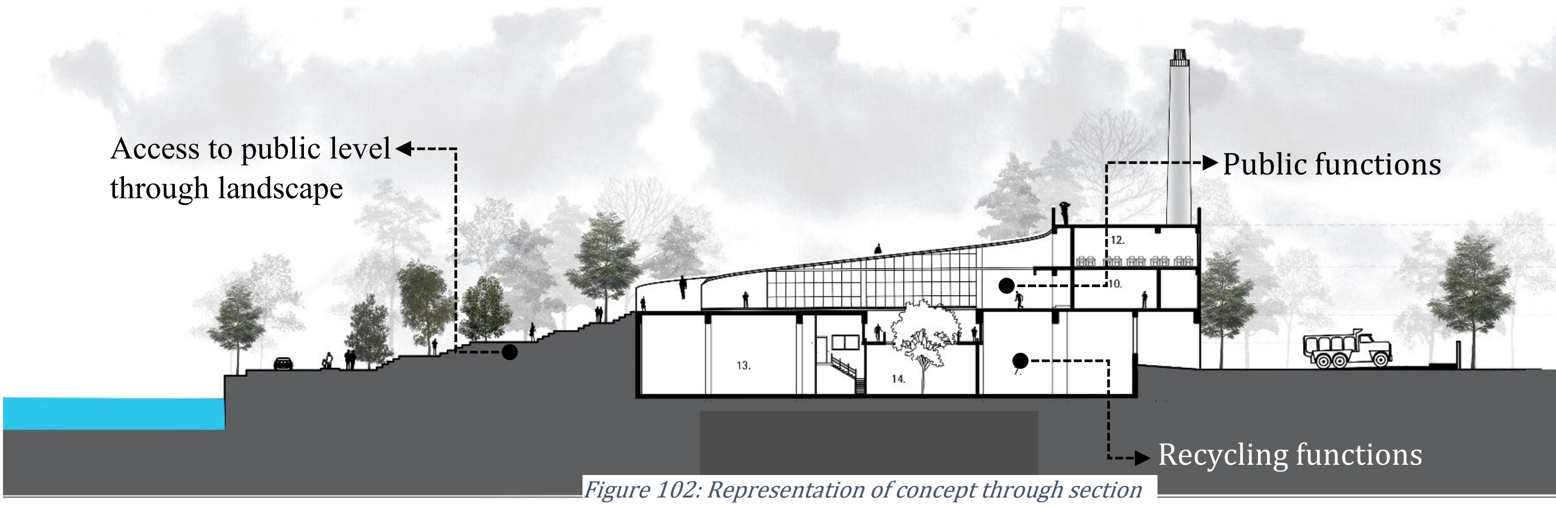


Figure 102: Representation of concept through section

6.2 FORM DEVELOPMENT

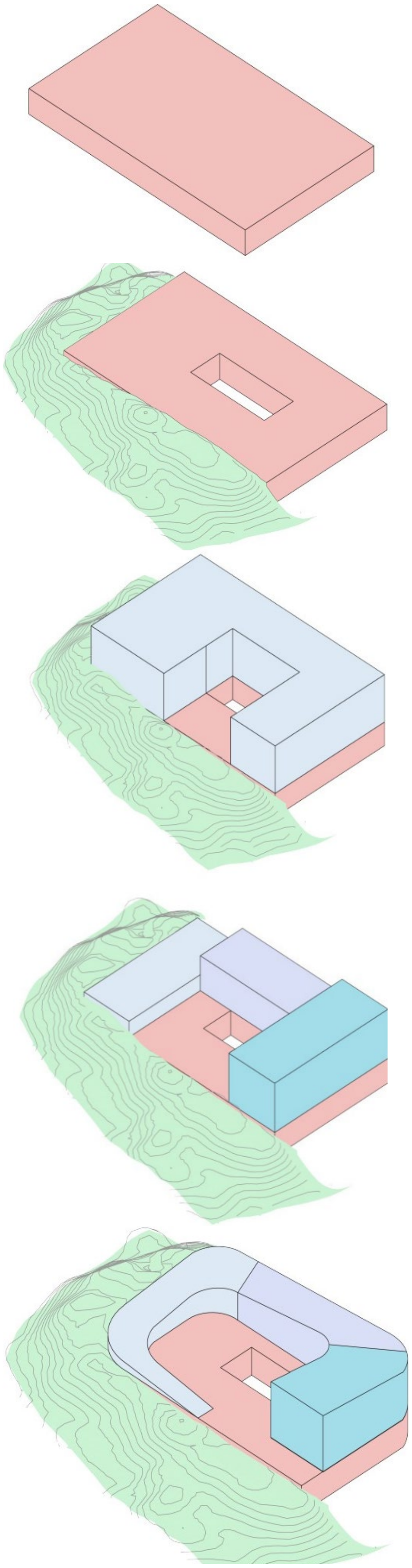


Figure 103: Form Development

INDUSTRY

The functional –industrial part is depicted by a very simple rectangular form for maximum functionality, efficient circulation, and a compact footprint. The volume is determined by the engineering and technical criteria

COURTYARD+LANDSCAPE

Courtyard is introduced for the natural lighting and ventilation for industry. Also included is a landscape that shields the industry from the public and provides access and spaces for public involvement.

FUNCTION FOR PUBLIC

Volume -extruded for public spaces and made necessary subtractions to let in sunlight into the courtyard.

TRANSFORMATION

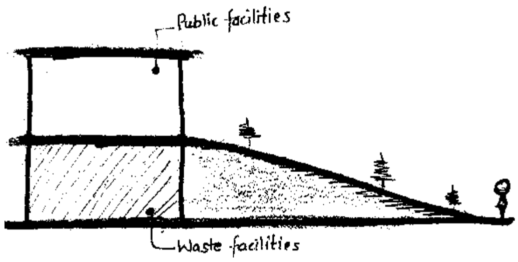
Massing of the extruded volume is done to emphasize public spaces as per requirement.

GREEN SLOPE ROOF

Slope to connect the landscape to the roof, enhancing the synergy between the existing river, landscape, and roof, and encouraging public activity on the green roof.

6.3 PLANNING DEVELOPMENT

The concept guided the building to be zoned vertically as waste recycling at lower part and public facilities at top of it as shown in fig. The further planning of the built and open spaces is done as per the ideas derived from the concept and functional requirement.

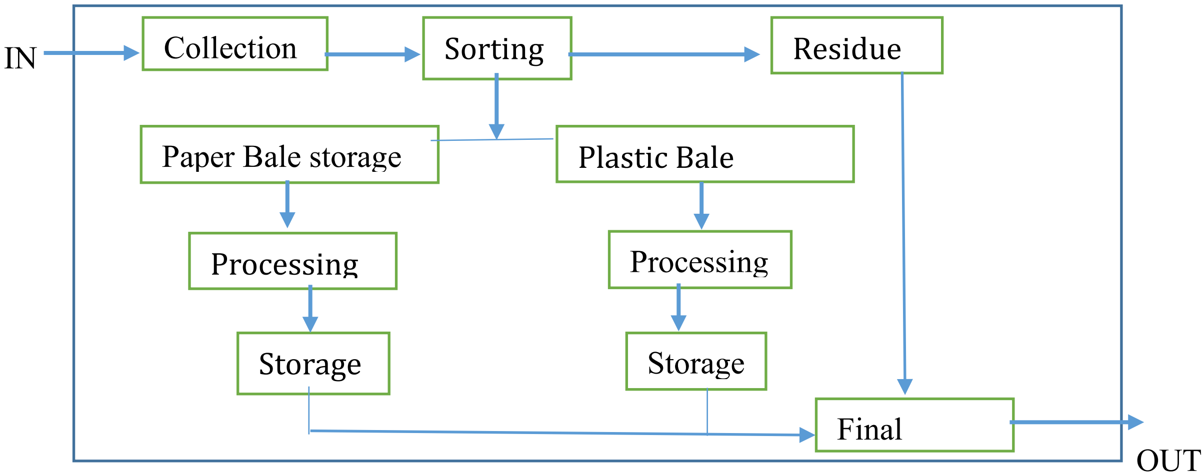


There is total separation of waste, staff and visitors transition throughout the building. Three entrances are provided, one for each entity.

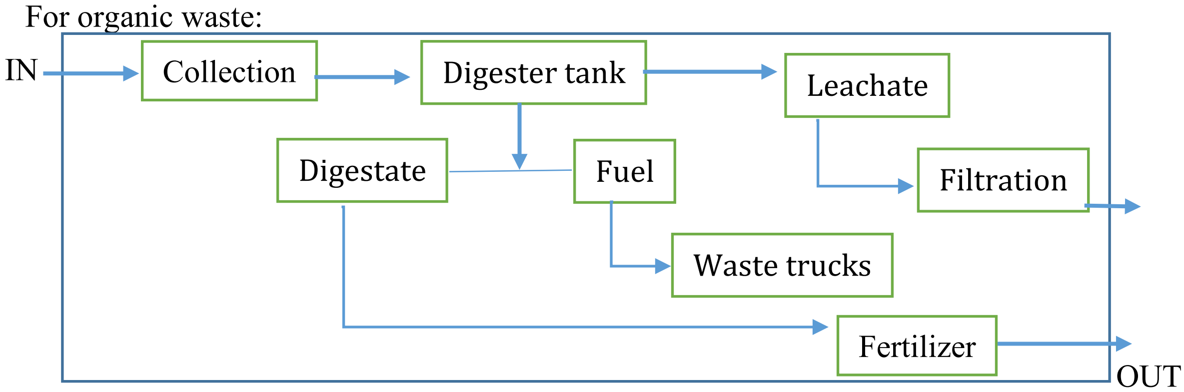
Waste facilities:

The entrance for the waste trucks is on the west. As waste enters the site, its circulation is minimized as much as possible throughout the site through careful planning. As a result, it is restricted to a linear road. A washing area for waste trucks is also provided in the north east corner of the site. The internal industrial planning is based on the flowchart of the function as shown:

For inorganic waste:



For organic waste:



The necessary supporting facilities such as storage, equipment room, electrical room, control room are also provided asper requirement.

Employees' facilities:

The staff entrance is located to the east. The parking facilities for staff s provided on the right after the entrance. The circulation of the staff within the building is also minimized so that they do not have direct contact with the public, reducing the risk of health hazards. As a result, the necessary amenities such as an office, first aid room, changing room, shower room, locker rooms, washing facilities, and a canteen are located on the lower level of the building.

Public facilities:

The public entrance is from the south. There is no physical barrier at the public entrance, with the idea that the landscape itself will serve as a buffer. The public is directly ascended to the industry's roof (+6000mm level) via the interactive landscape, which directs them to the plaza, from which they can access either to the green roof or the inside the building.

As, people enter inside the building, there is information center on the lobby and other available functional spaces for public are such as administration, education center, conference, and restaurant. Exhibition hall, café and shops can be accessed directly through plaza. The conference hall and restaurant are also accessible via the green roof. Visitors/researchers willing to participate in viewing and learning about the recycling process can also overlook the waste recycling process via the provided platform.

Table 2: Floor wise distribution of function

Floor level	Waste facilities	Staff facilities	Public facilities
-3000 mm	• Collection area • Processing area • Storage • Equipment room	• Changing and locker room • Shower room	-
+/-0000mm	• Control room • Storage • Docking area	• Office • Staff room • First aid room	-
+3000mm		• Canteen	• Viewing platform
+6000mm	-	• Administration • Information Centre	• Exhibition hall • Café • Shops
+10300mm	-	• Office • Training center	• Workshop • classrooms
+14300mm	-	-	• Conference • Restaurant
+18300mm	-	-	• Restaurant

(Refer to Annex AR-07 / AR-08/AR-09/AR-10 for floor plans and section)

6.3.1 LANDSCAPE DESIGN

The landscape forms an integral part of the design as the main idea of the project is to engage public in waste recycling facility through green –open spaces. The concept of landscape design is to create a green - public space, in the midst of a densely populated city area, with the primary goal of creating a Green Park for the city.

The landscape design approach starts with the concept of drawing the public directly to +6000 mm level, which later led to the idea of creating an artificial hill that directly ascends the public to the roof of the industrial part.

The landscape design revolves around creating spaces for public engagement that promote inclusiveness, such as various pocket spaces for interaction, playing areas, open air theaters, gathering spaces, walking trails etc.

The landscape design is also intended to be as a riverfront development for the Bishnumati River situated at the southern side of the site that would rejuvenate the essence of river which at present is in declined state due to improper waste disposal.

Public interaction space

As the concept of the design was to create a communal space, interactive spaces are provided on various levels with the provision of stepped seating's where one can rest and enjoy the natural atmosphere in nature garden, while chatting with friends and families.

Walking trails and kiosks

The walking trails have been designed to provide a longer and more relaxed journey through the landscape, allowing users to experience the natural journey. One can also find kiosks and seating area while strolling.

Play area and car parking space

A deck is built that provides semi-covered parking while also providing space for playing and fun activities. There is also an open-air theatre built on natural land where visitors can watch the fun activities.

Figure 104: Landscape design

6.3.2 GREEN ROOF DESIGN

The green roof in the design is the main draw for the public. The green roof ascends in slope in order to integrate the landscape with the building. Extensive green roofs that require little maintenance is a key component in the project's design, as they contribute to the building's sustainability while also increasing its essence.

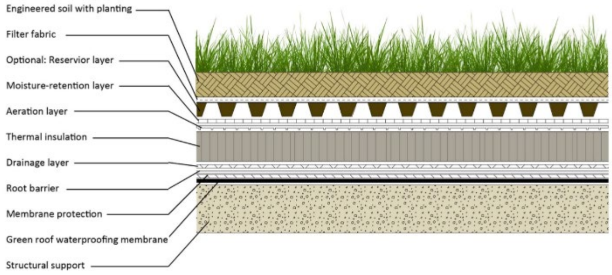


Figure 105: Green roof details

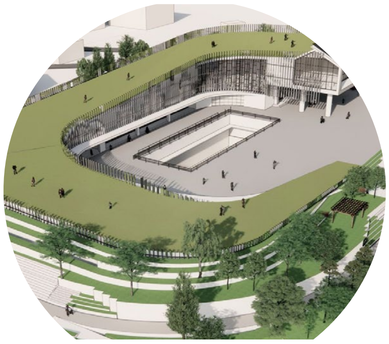
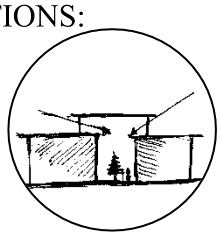


Figure 106: Green roof design

The green roof serves as a green park, offering a place to relax, a path for strolling, and a new experience in Nepal. On occasion, this green roof is used to display various recycled objects, allowing people to learn about recycling and understand its importance. In addition, the green roof advocates for even more green space in the city.

DESIGN CONSIDERATIONS:

Optimal sunlight



Courtyard

Communal Space

Green roof

Figure 107: Birds eye view of the building

6.4 STRUCTURE ANALYSIS

The structural system is determined by the type of function and the spatial requirements demanded by the function. For efficiency and functionality, the recycling facility requires space with an uninterrupted open huge span. As a result, post tensioning system is used to support long spans for the least deflection as possible.

6.3.3.1 Post tensioning system:

Post-tensioning is a prestressing technique in which the tendons are tensioned after the concrete has hardened, and the prestressing force is primarily transferred to the concrete via the end anchorages. The concrete component is cast with steel reinforcing strands that are installed in such a way that they do not bond with the concrete. This practice allows designers to further optimize material use by constructing thinner concrete members. The materials used to post-tension concrete members are ultra-high-strength steel strands and bars.(*Posttensioned Concrete*)

Benefits of post tensioning system over reinforced concrete:

- Post tensioning provides greater architectural flexibility with space and form.
- It provides large clear span and minimized floor to floor height as depth beam is reduced.
- Improved deflection criteria: The deflection of PT members is lesser as compared to that of RCC.
- As high strength concrete is used, PT has more strength and can bear greater load as compared to RC.

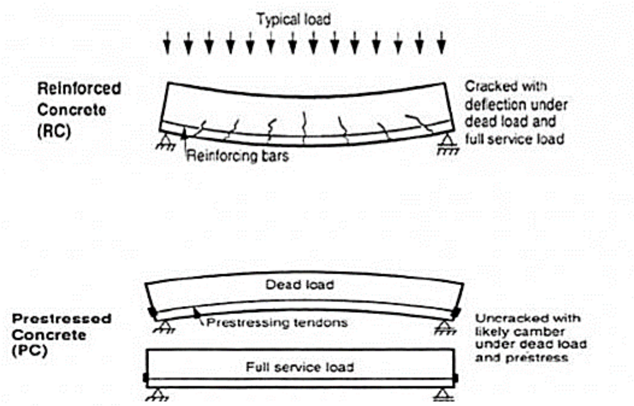


Figure 108: RCC vs Post tensioning

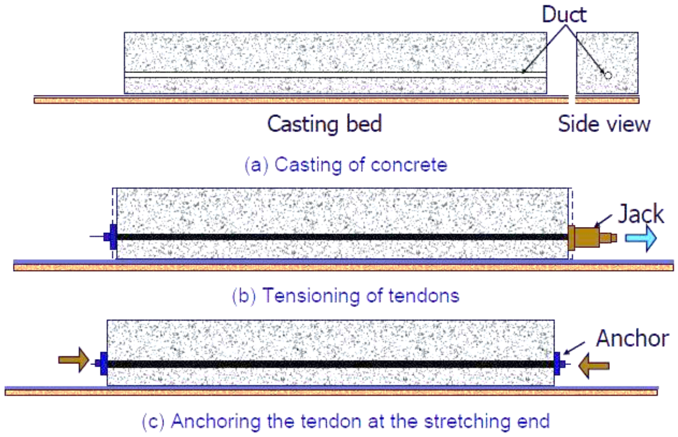
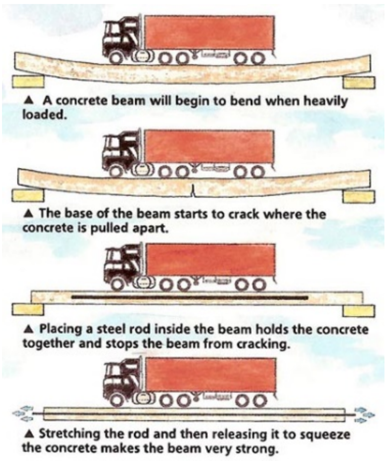


Figure 109: Working principle of Post tensioning system



Calculating column size

Concrete of M40 and steel of Fe500 is used

We have

- Number of floors=5,
- Slab Span= 70m ×25m,
- Total number of columns = 18,
- fy=500N/mm2,

- fck=40N/mm2, thumb rule load=20kN/m2,
- Gross area Ag =100%,
- Steel area, Asc =1%ofAg =0.01Ag and
- Concrete area Ac =99%of Ag =0.99Ag.

Load = 5×20kN/m^2 ×70m×25m = 175000kN,
Load acting on each column=175000kN/18=9723kN,

Consider 10% increasing load on each column for safety factor,
10% of 9723 =972.3kN,
So total axial load acting on each column=9723+972.3=10695.3,
Putting this value in in formula,

Pu=0. 4fck.Ac + 0. 67fy.Asc,
10694.5 KN =0.4 ×25×0.99Ag + 0.67×500×0.01Ag
10694.5 ×10^3 = 15.84Ag +3.685Ag
10694.5 ×10^3 = 19.525Ag
Ag (Gross area) =10694.5×10^3/19.525= 547733.68,
Suppose we square column, so area of square =a2, hence a^2 = 547733.68mm2,
a=√547733.68mm2=740mm,

- Width and depth of column =740mm×740mm, taking in round figure=**800mm×800mm**

Similarly, column size of 600*800 mm and 600*600 mm are used depending on the number of floor and the maximum span of 20 m.

(Refer to Annex ST-01 for Structure plans and details)

6.5 SERVICES AND UTILITIES

6.5.1 Water supply:

The underground tank serves as the primary water reservoir for storing water, then the water is distributed to respective fixtures via pneumatic pump, and the water tank capacity is calculated in accordance with NBC 203:2008, as shown below:

Table 3: Water requirement calculation

	No. of users	Quantity per day	Total lpcd
Factory	45	45 lpcd	2000
Administration (Office)	25	45 lpcd	1100
Workshop	50	15 lpcd	750
Cafeteria	50	50 lpcd	2500
Restaurant	120	50 lpcd	6000
Park		1000 lpcd	1000
Conference	150	15 lpcd	2250
Others		1000 lpcd	1000
		TOTAL	**16600Lpcd**
			17 m^3

Total consumption of water per year=17*365=6205m^3

Size of underground tank =3*volume (safety factor=3)

=3*17=51 m3=5*3.5*3(L*B*H)

Firefighting tank requirement (NBC) = 50 m^3=5*3.5*3(L*B*H)

6.5.2 Sewerage:

The septic tank and soak pit are located in the north-west corner of the site and collect sewerage from toilets, kitchens, and showers via soil manhole for solid waste and waste manhole for waste water.

Calculation of septic tank and soak pit capacity:

- Total peak no. of user: 400
- Expected user: 50%=200

Based on IS 2470, for up to 200 users, the size of septic tank is as follows:

L=12m; B=3.3m; H=1.8 m

Similarly, the size for soak pit is:

Diameter (D) =5m; depth (H) =2.75m (from standard)

(Refer to Annex SR-01 for sanitary plans (water supply, rainwater harvesting and sewerage))

6.6 DESIGN AMENITIES

6.6.1 Sustainability:

As a waste recycling center, the project must stand for sustainability in order to have the least impact on the environment. The project has used a multitude of sustainable and energy-efficient approaches, including followings:

6.6.1.1 Energy consideration:

- **Photovoltaic cells**

Solar panel is provided on the southern part of roof top. Monocrystalline solar panel with 15% efficiency that yields 300 wattage of power is used.

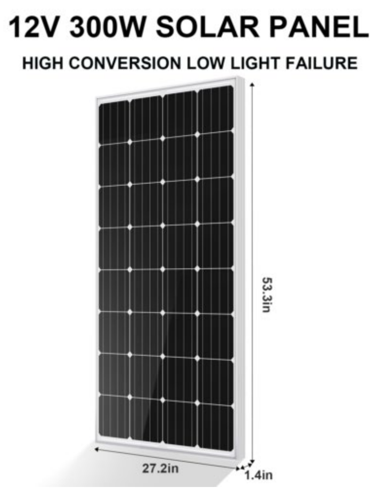


Figure 110: Monocrystalline solar panel

Electricity generated by the photo-voltaic cells:

Power in watt: 300 W

Size of monocrystalline solar panel: 1.64*0.99*3.5

Daily watt hours=300*6=1800wh=1.8kwh/day

Available roof area=25*8=200

No. of solar panel=200/1.64=121

Total energy production:121*1.8=217.8kwh/day

Energy consumption:

1 sq. consumes =0.05 Kwh/day

Total floor area: 14500 m2

Total energy Consumption: 14500*0.05=725Kwh/day

HENCE, PHOTOVOLTAIC CELLS SATISFIES ABOUT 30% OF THE TOTAL ENERGY REQUIREMENT.

- **Bio-fuel**

The fuel produced from anaerobic digestion of organic waste is used in waste trucks as fuel. Organic waste is collected and delivered to an anaerobic digester to stabilize and optimize methane production. The resulting biogas can be processed into RNG and used to fuel natural gas vehicles.

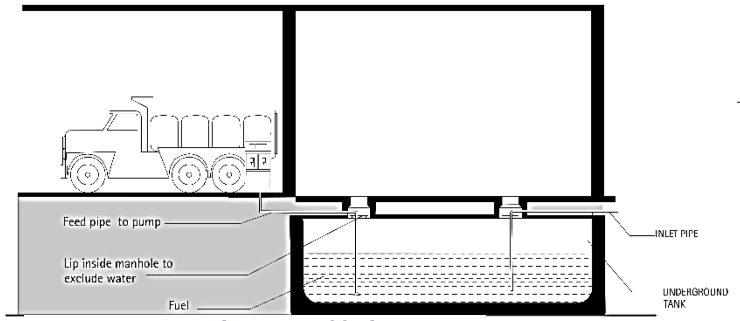


Figure 111: Typical section of fuel station

Biogas fuels generally emit little pollution into the atmosphere and, because they are derived from renewable energy sources, have a high potential for future use. Thus, this vehicle fuel is the most effective way to recycle waste.

6.6.1.2 Rainwater harvesting

The concept of rain water harvesting is major one for the sustainability.

Green roof and the plaza is the major catchment area for the rainwater. The collected rainwater is cleaned and filtered before being stored in the main rainwater tank. It is primarily used to flush toilets, washing facilities, water plants, and in the recycling process.

Calculation,

Total catchment area: 4550 m^2
Runoff coefficient: 0.6
Average Annual rainfall of Kathmandu: 1397mm
Annual rainwater harvesting potential: =4550*0.6*1.4
=3822m3/year
=3820000litres/year

Calculation of tank size for rain water harvesting =5% of Annual potential

(Size of rainwater tank must at least be 5% of annual rainwater yield)
=5/100*3800=190 m^3
=6.5*10*3

RAIN WATER HARVESTING SATISFIES ABOUT 60% OF WATER REQUIREMENT.

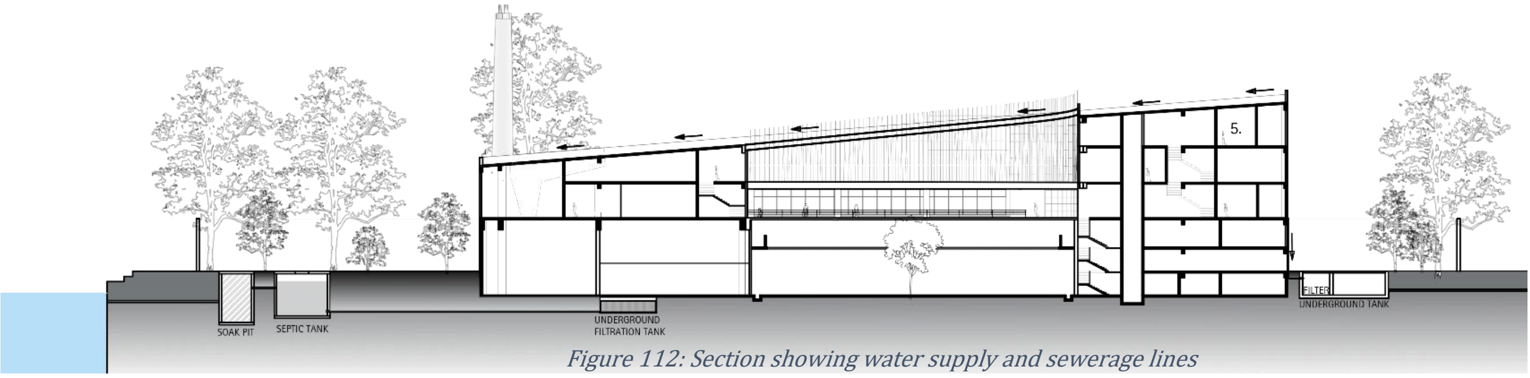


Figure 112: Section showing water supply and sewerage lines

6.6.1.3 Green roof:

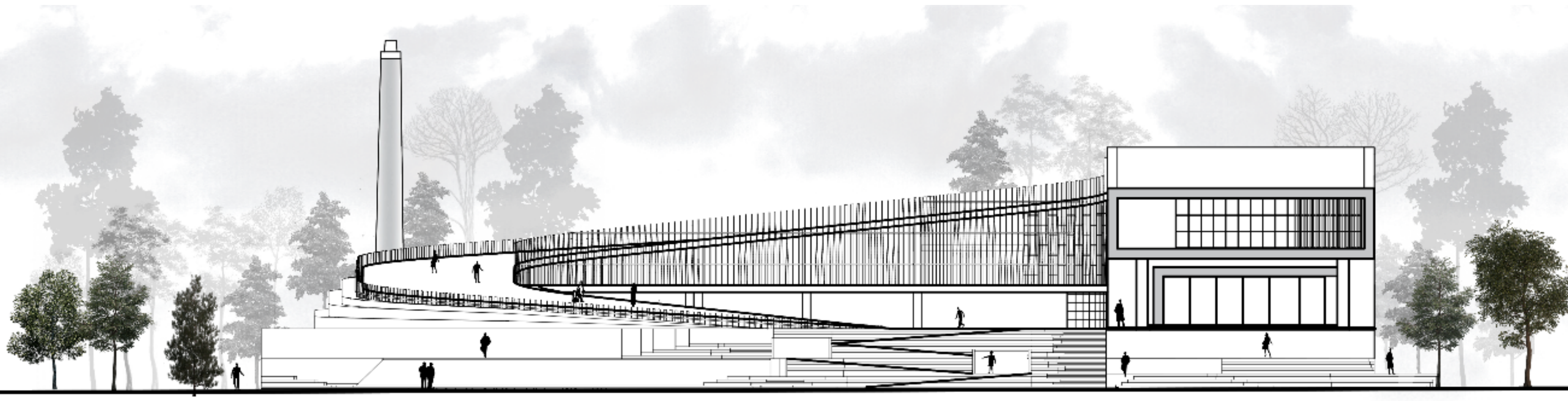
The green roof is the project's main design element as it's more aesthetically pleasing than traditional roofs and contributes to the building's sustainability. Green roofs can help to reduce air pollution by absorbing pollutants and greenhouse gases such as carbon dioxide, implying a positive environmental impact. Green roofs are better for the health as well it significantly increases air quality. Also, green roof reduces the need for air conditioning during the summer and provides insulation during the winter.

6.6.2 Twisted façade screening:

Twisted façade screening has been used on the elevation. The idea of Screening is derived from the concept that the lotus has a waxy surface that screens dust and dirt despite blooming on the mud. Furthermore, the screening provides an integrated look at the form.

(Refer to Annex AR-12 for elevations)

Figure 114: Twisted facade screening



FRONT ELEVATTION

Figure 113: Use of screening in elevation

6.6.3 Lighting

In accordance with the concept, the industrial part becomes a semi-basement for the general public, i.e., it is partially submerged beneath the land. As a result, Courtyard is introduced for natural lighting and ventilation in industrial part. In addition, walkable skylights have been provided on the plaza through cutouts to allow light to penetrate.

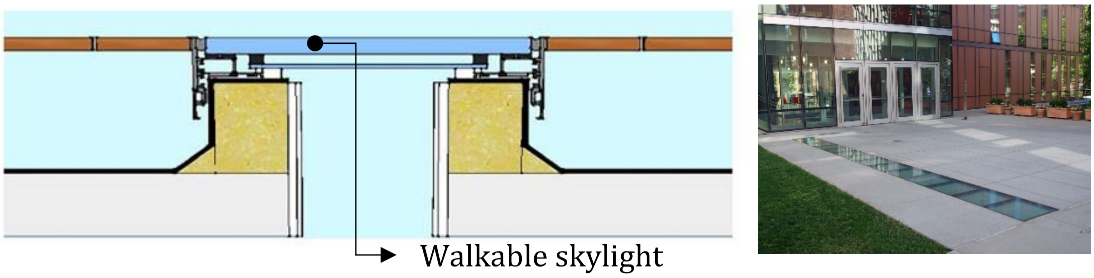


Figure 115: Use of walkable skylights

6.6.4 Vegetative buffer:

Since the site faces the major problem of smell and sound pollution due to waste and vehicles, in order to reduce the problem of odor and sound to nearby residential areas, the idea of Vegetative earth buffering is used. Vegetative buffers- consisting of a minimum of three tree and shrub species that are properly sized and positioned are an effective odor control practice. ("Vegetative Buffers to Control Odors on Livestock Farms")

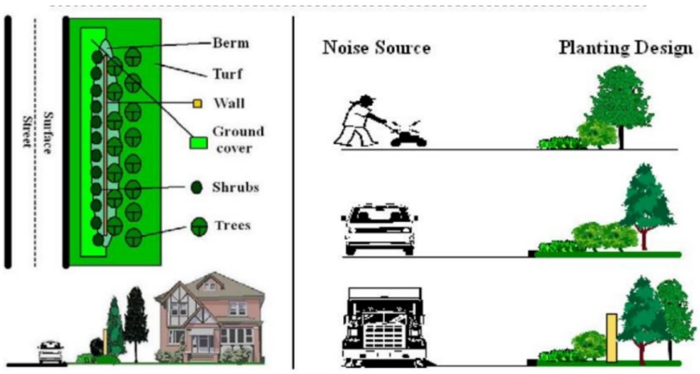


Figure 116: trees as buffers

7. CONCLUSION:

In the current situation, addressing the waste management system of Kathmandu Metropolitan City is crucial due to the rapid increase in waste production, which poses significant health and environmental risks. To tackle this issue, designing a Waste Recycling Center could be a suitable solution. Moreover, incorporating public spaces within these facilities would enhance their value and promote community interaction. Thus, the design aims not only to serve as a recycling center but also as a place for public engagement through the careful addition of green spaces to the city.

When designing a waste recycling center, creating a functional flow of spaces is crucial aspect as it relies on the efficient workflow of machineries. Key considerations include determining the space requirements based on waste volume and ensuring that the equipment meets technological capabilities. Additionally, it is crucial to prioritize the well-being of employees working in such centers, providing them with adequate facilities to manage the associated risks.

Hence, the project's design posed a challenge in finding architectural solutions for technical issues and successfully integrating waste management and public spaces without their immediate proximity. The Waste Recycling Center has been carefully planned to efficiently recycle organic and inorganic waste (such as plastic and paper) while producing the desired raw materials. Simultaneously, it offers a green space within the city where the public can interact, relax, and enjoy. To add on more to it, the design of waste recycling center also advocates for the promotion of sustainability, causing less impact to the society and environment.

Thus, the center's attempts to reduce waste, create public spaces, prioritize employee well-being, and promote sustainability can serve as a model for other cities.

FINAL OUTCOME:

Figure 117: Final model

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ANNEX

DESIGN DRAWINGS

SUBMITTED BY:

MANISHA SHRESTHA

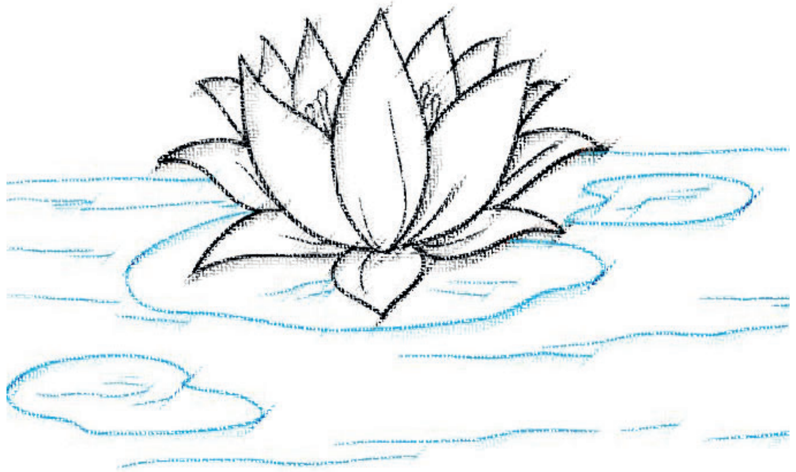
074BAE218

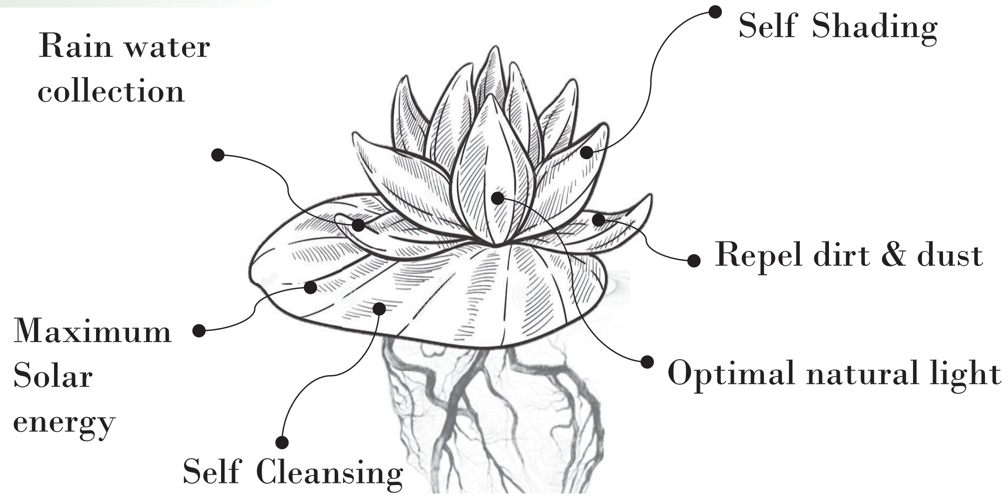
DATE: May,2023

WASTE RECYCLING CENTER for Kathmandu Metropolitan City

FORM DEVELOPMENT

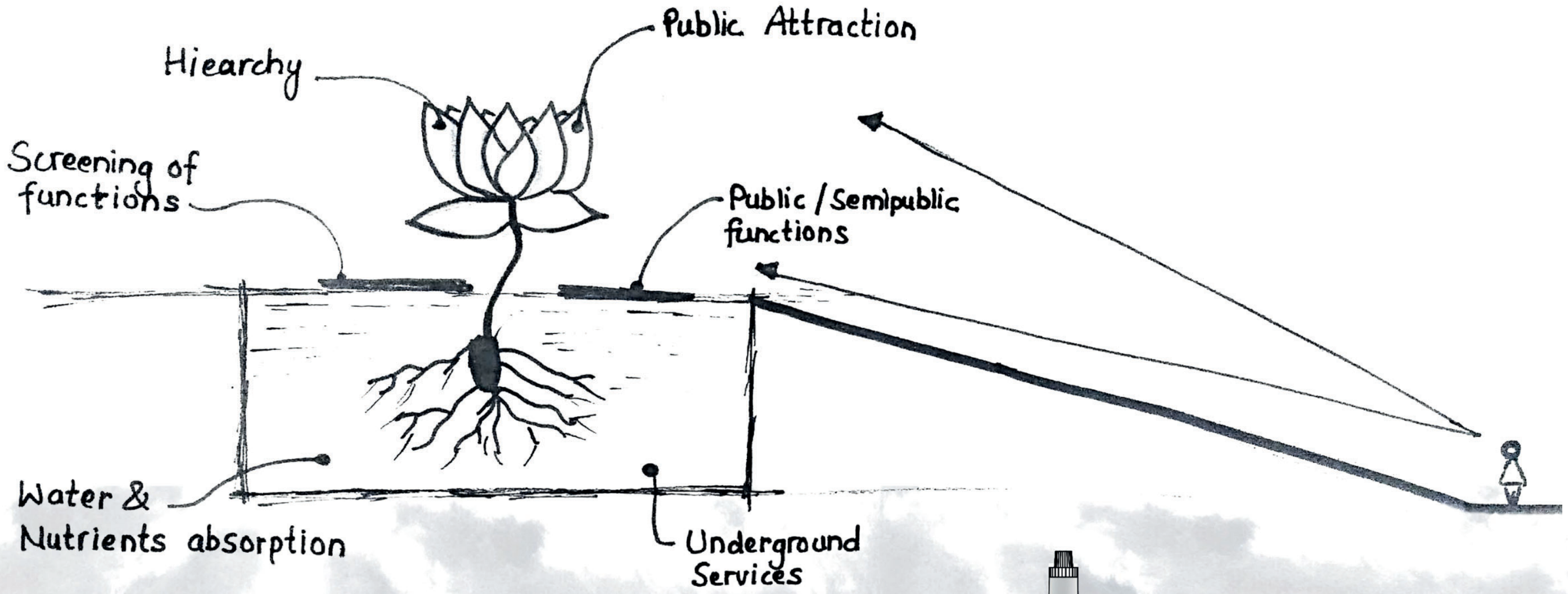
"A LOTUS BLOOMS IN THE MUD"

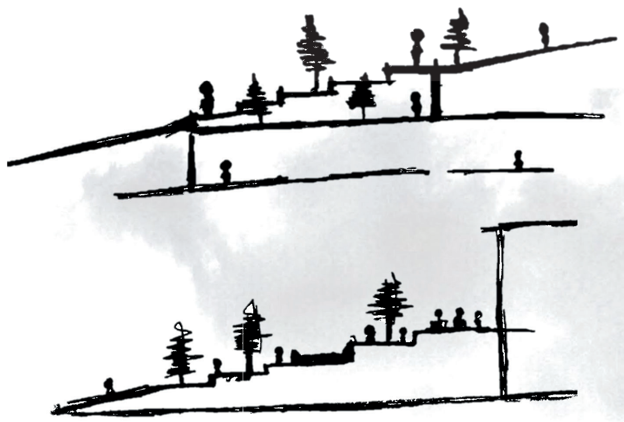




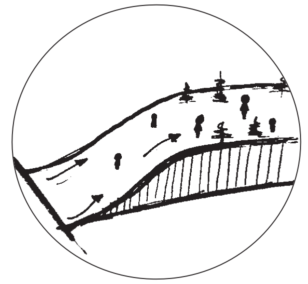
SUSTAINBILITY
WASTE
REBIRTH
PUBLIC
EMPLOYEES
LANDSCAPE
NATURE
PROGRESS
BEGINNING
CONNECTIVITY

- **JUXTAPOSITION:** of beauty from ugliness.
- Symbol of **RE-BIRTH**
- Mud signify waste
- Blooming of the lotus signifies the hope for **positive change**

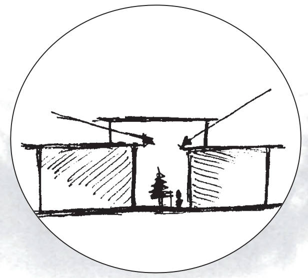




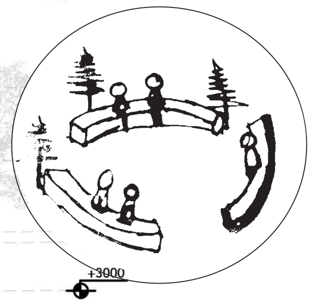
SUN ORIENTATION



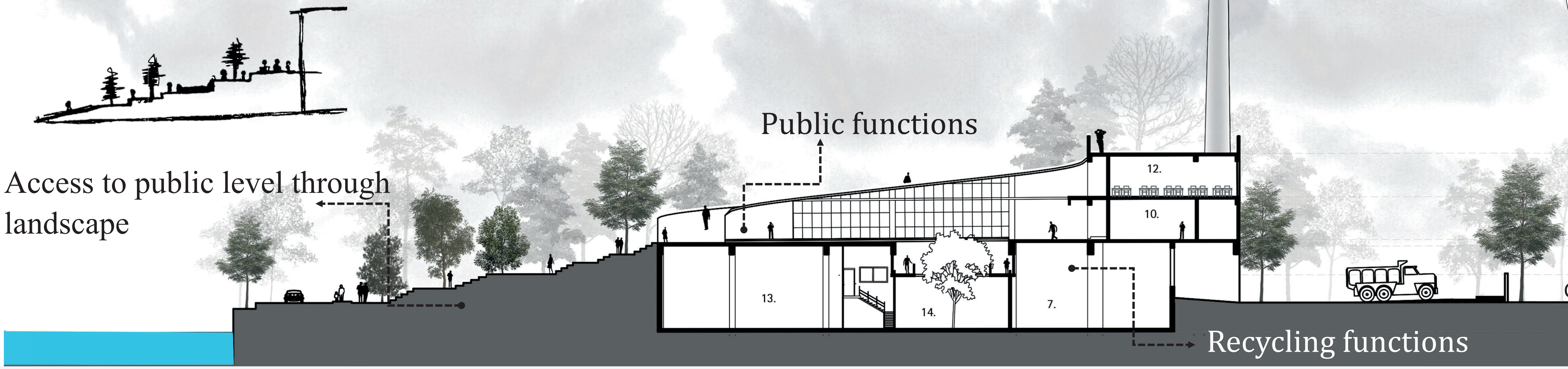
GREEN ROOF



COURTYARD

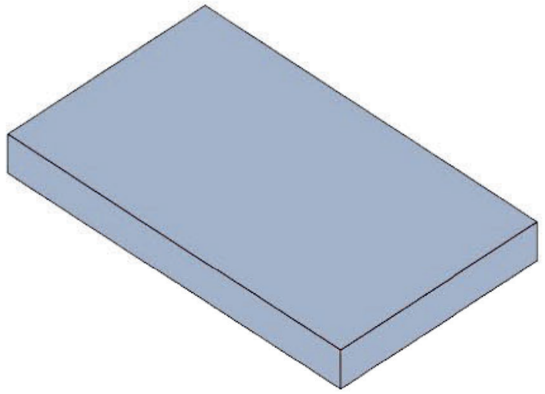


COMMUNAL SPACES



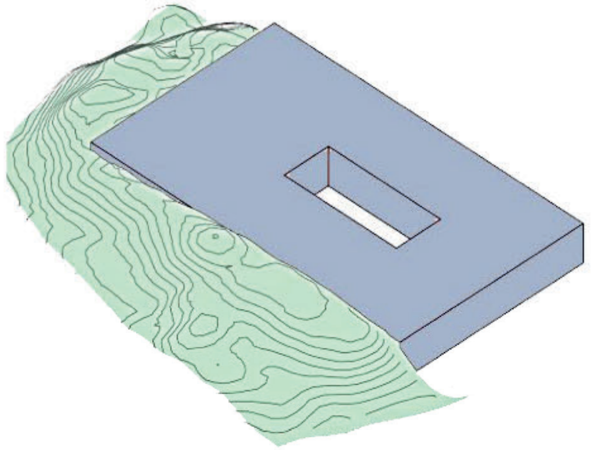
WASTE RECYCLING CENTER for Kathmandu Metropolitan City

FORM DEVELOPMENT



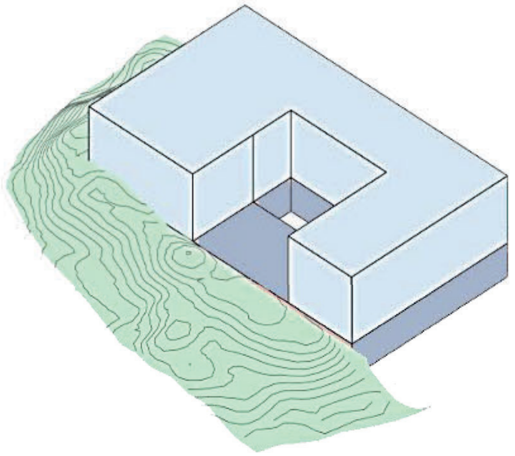
INDUSTRY

Rectangular form for maximum function , efficient circulation and compact footprint



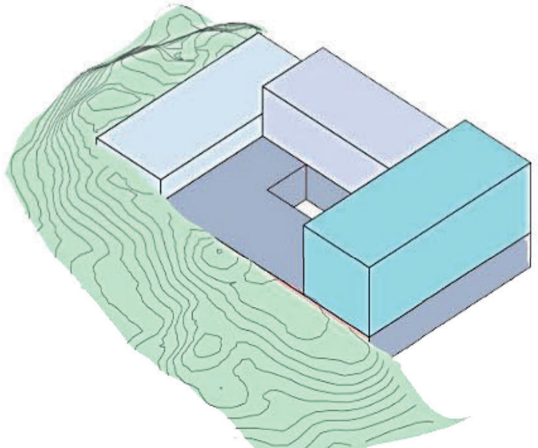
COURTYARD+LANDSCAPE

Landscape to cover industrial unit from public and provide spaces for public engagement



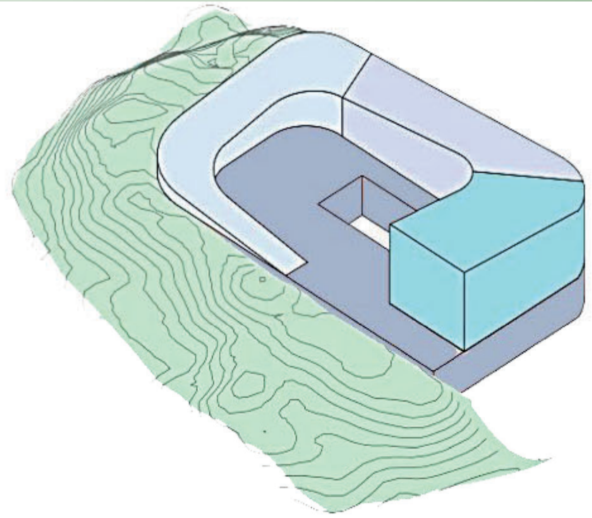
FUNCTION FOR PUBLIC

Extruded the cuboidal form Subtracted the volume in front to let in sunlight



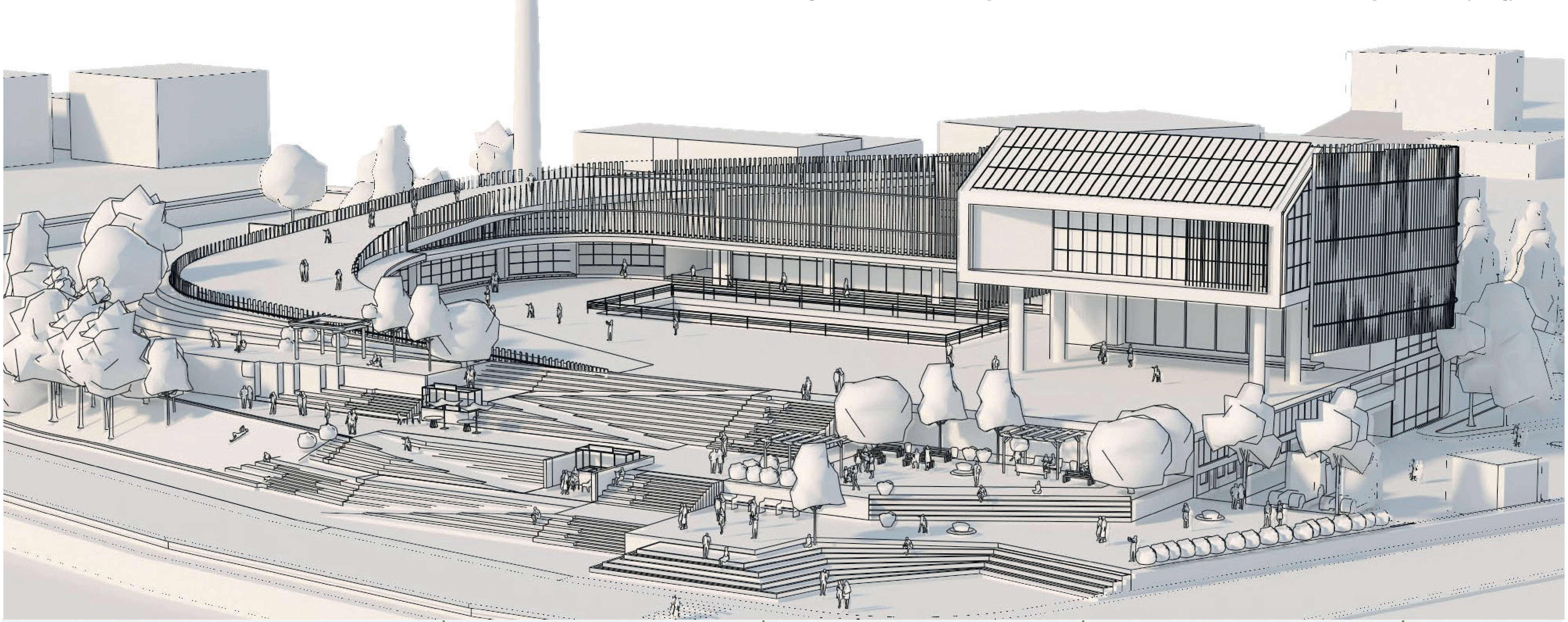
TRANSFORMATION

The extruded volume is massed to emphasize public spaces as required.



GREEN SLOPE ROOF

Slope connects the landscape to the roof, enhancing the existing river, landscape, and roof synergy,

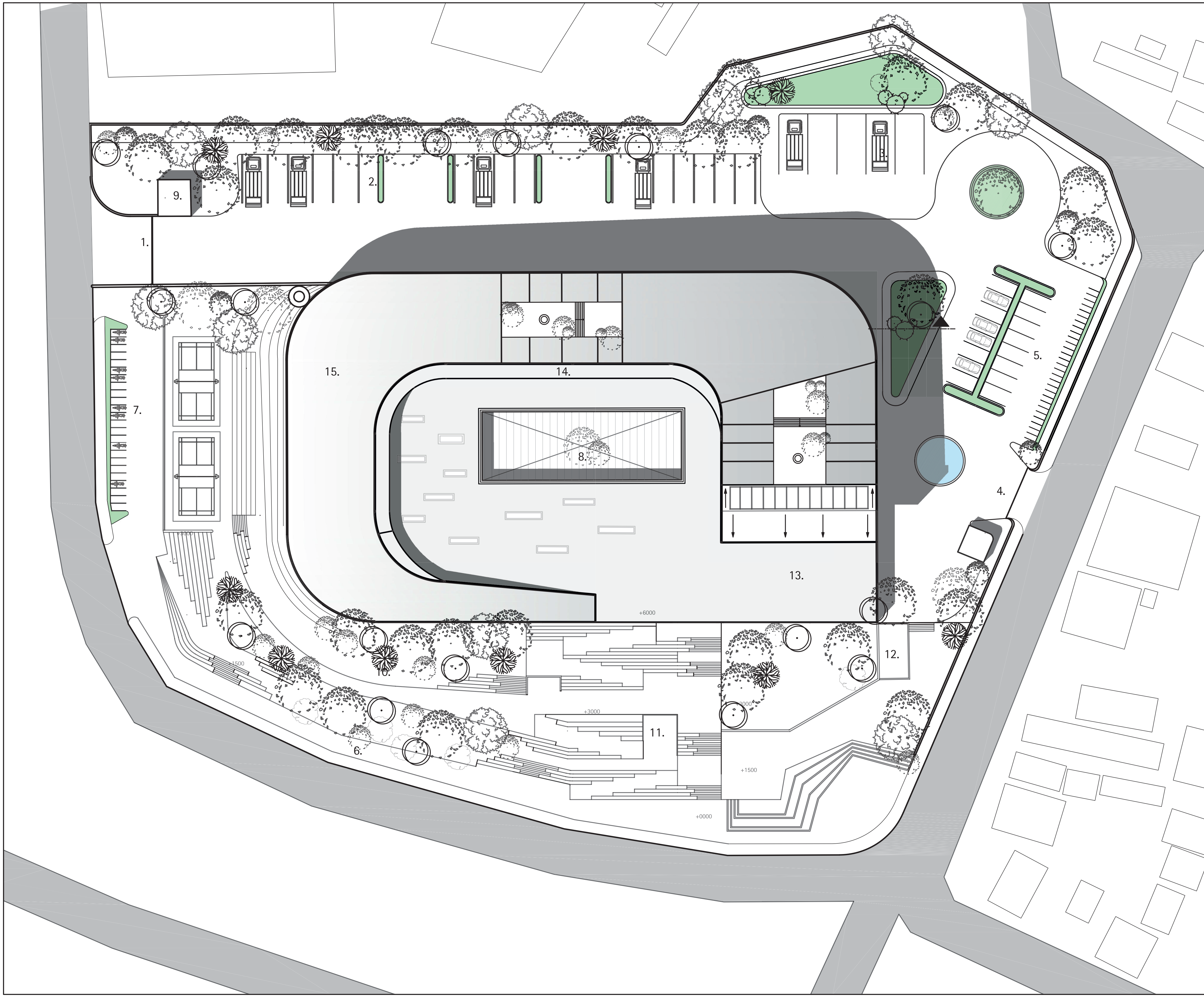


INSTITUTE OF ENGINEERING
DEPARTMENT OF ARCHITECTURE
PULCHOWK , LALITPUR

SHEET TITLE:
FORM DEVELOPMENT

THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

MANISHA SHRESTHA
ROLL:074BAE218



N

INDEX

1.WASTE ENTRY
2.WASTE TRUCK PARKING
3.VEHICLE WASHING AREA
4.STAFF ENTRANCE
5.STAFF PARKING
6.PUBLIC ENTRANCE
7.PUBLIC PARKING
8.COURTYARD
9. GUARD HOUSE
10. PARK
11.KIOSKS
12. PUBLIC TOILET
13.RECYCLING BLOCK
14.PUBLIC BLOCK
15. GREEN ROOF

TU, IOE
PULCHOWK CAMPUS
DEPARTMENT OF ARCHITECTURE
PULCHOWK LALITPUR

THESIS TITLE:
WASTE RECYCLING CENTER
FOR KATHMANDU METROPOLITAN CITY

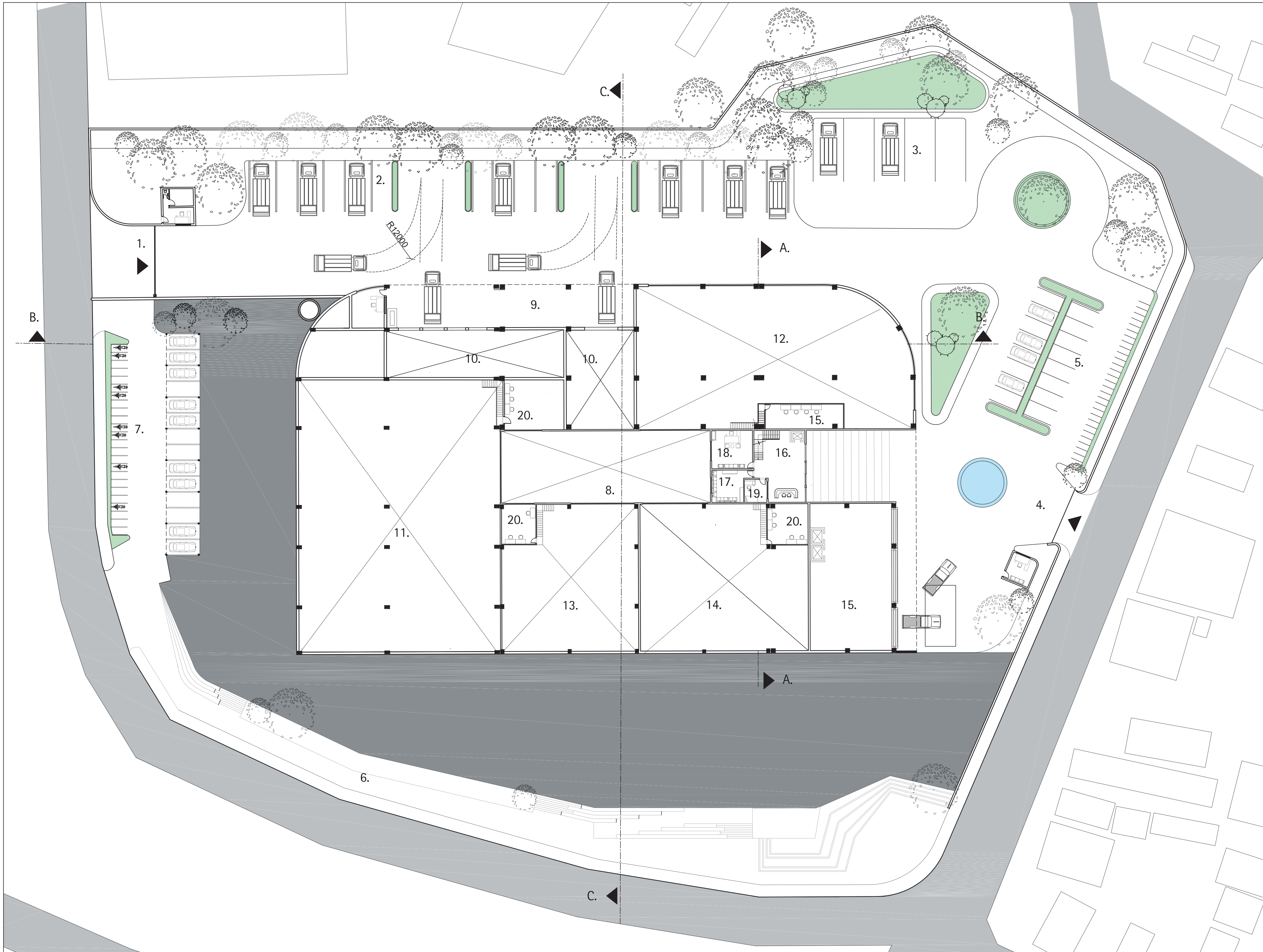
THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
SITE PLAN WITH ROOF

SCALE :1:300
DATE :080-01-10

SHEET NO. : AR 07



SITE PLAN WITH GROUND FLOOR PLAN
(± 0000 LEVEL)
SITE AREA:19389 SQ.M
GROUND COVERAGE:6022 Sq.m. (32%)

INDEX
1.WASTE ENTRY
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5.STAFF PARKING
6.PUBLIC ENTRANCE
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12.MATERIAL RECOVERY FACILITY
13. PAPER RECYCLING FACILITY
14. PLASTIC RECYCLING FACILITY
15.STORAGE
16.RECEPTION/LOBBY
17.STAFF ROOM
18.OFFICE
19.FIRST AID ROOM
20.CONTROL ROOM

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DEPARTMENT OF ARCHITECTURE
PULCHOWK LALITPUR

THESIS TITLE:
WASTE RECYCLING CENTER
FOR KATHMANDU METROPOLITAN CITY

THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

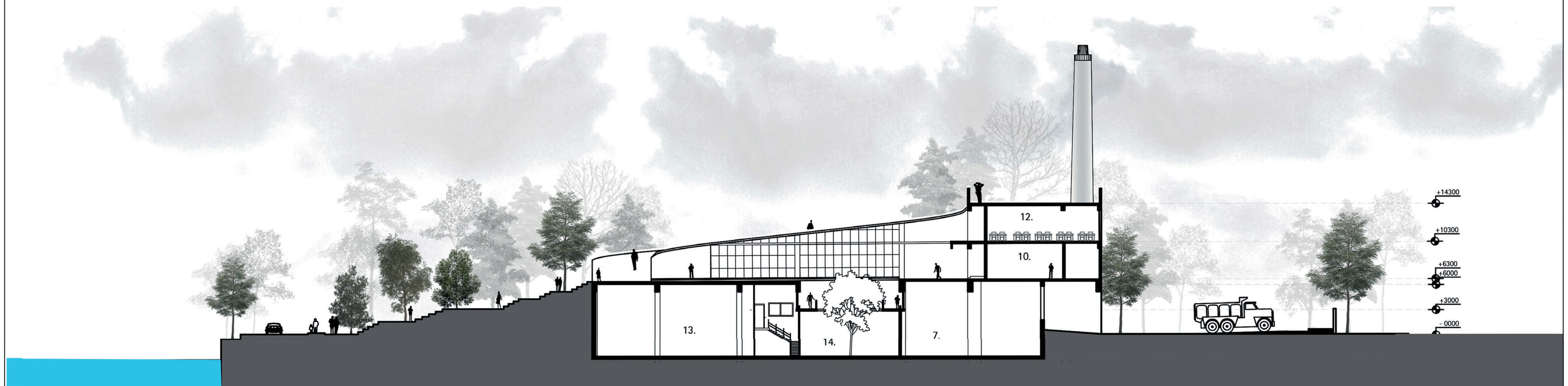
SHEET TITLE:
SITE PLAN WITH GROUND FLOOR PLAN
(± 0000 LEVEL)

SCALE :1:300(IN A1)
DATE :080-01-10

SHEET NO. :AR 08

SECTION AT A-A

SECTION AT B-B



SITE SECTION AT C-C

INDEX

1.MATERIAL RECOVERY FACILITY
2.PAPER RECYCLING
3.ADMINISTRATION
4.WORKSHOP STUDIO
5.CONFERENCE HALL
6.RESTAURANT
7.WASTE BUNKER
8.EXHIBITION HALL
9.CAFETERIA
10.SHOPS
11.TRAINING CENTER
12. CLASSROOM
13.PAPER RECYCLING
14. COURTYARD
15. ORGANIC WASTE
PROCESSING UNIT

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DEPARTMENT OF ARCHITECTURE
PULCHOWK LALITPUR

THESIS TITLE:
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FOR KATHMANDU METROPOLITAN CITY

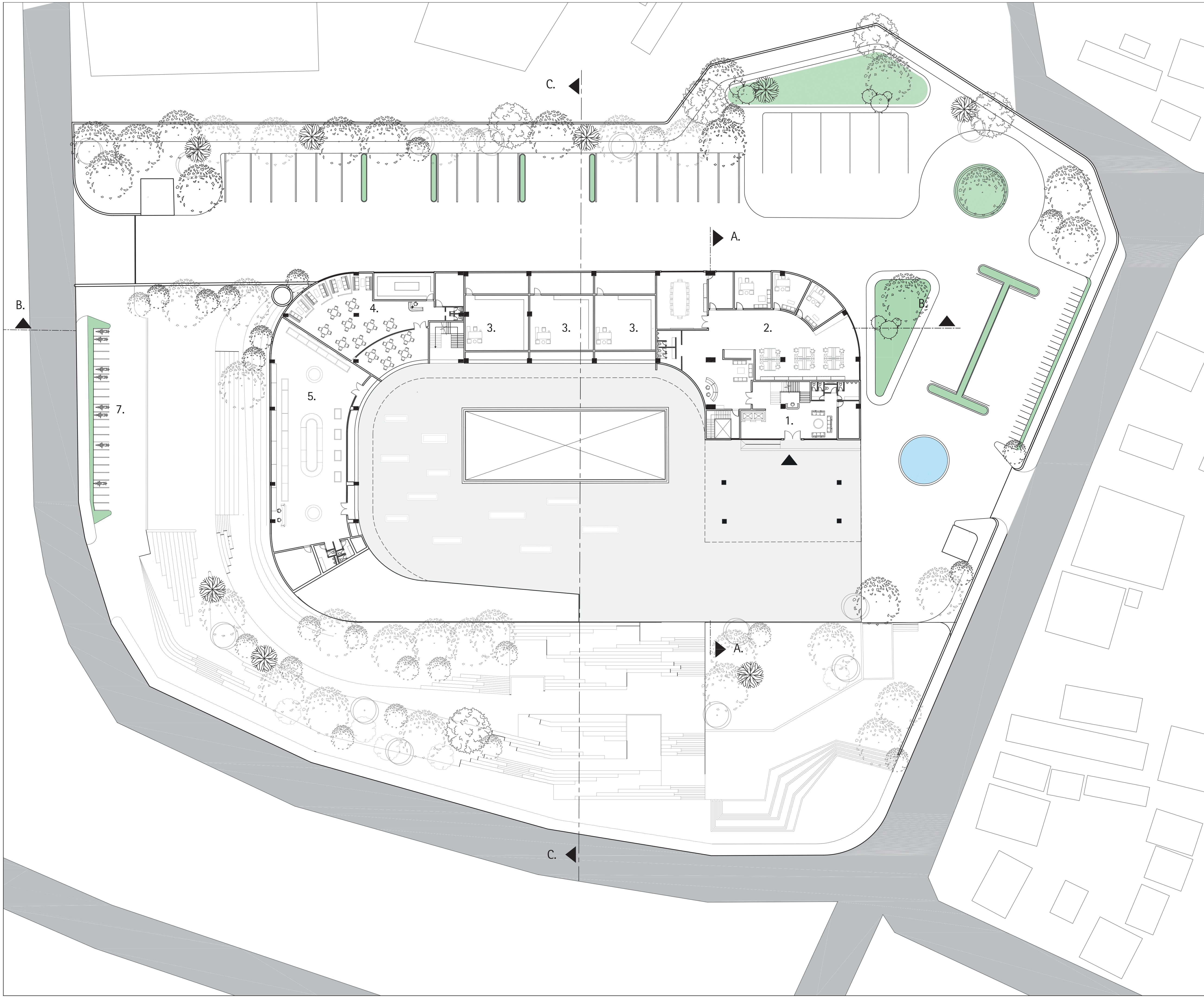
THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
SECTIONS

SCALE :1:300(IN A1)
DATE :080-01-10

SHEET NO. :AR 09



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1.LOBBY/RECEPTION
2.ADMINISTRATION
3.SHOPS
4.CAFETERIA
5.EXHIBITION HALL
6.PUBLIC ENTRANCE
7.PUBLIC PARKING
8.COURTYARD

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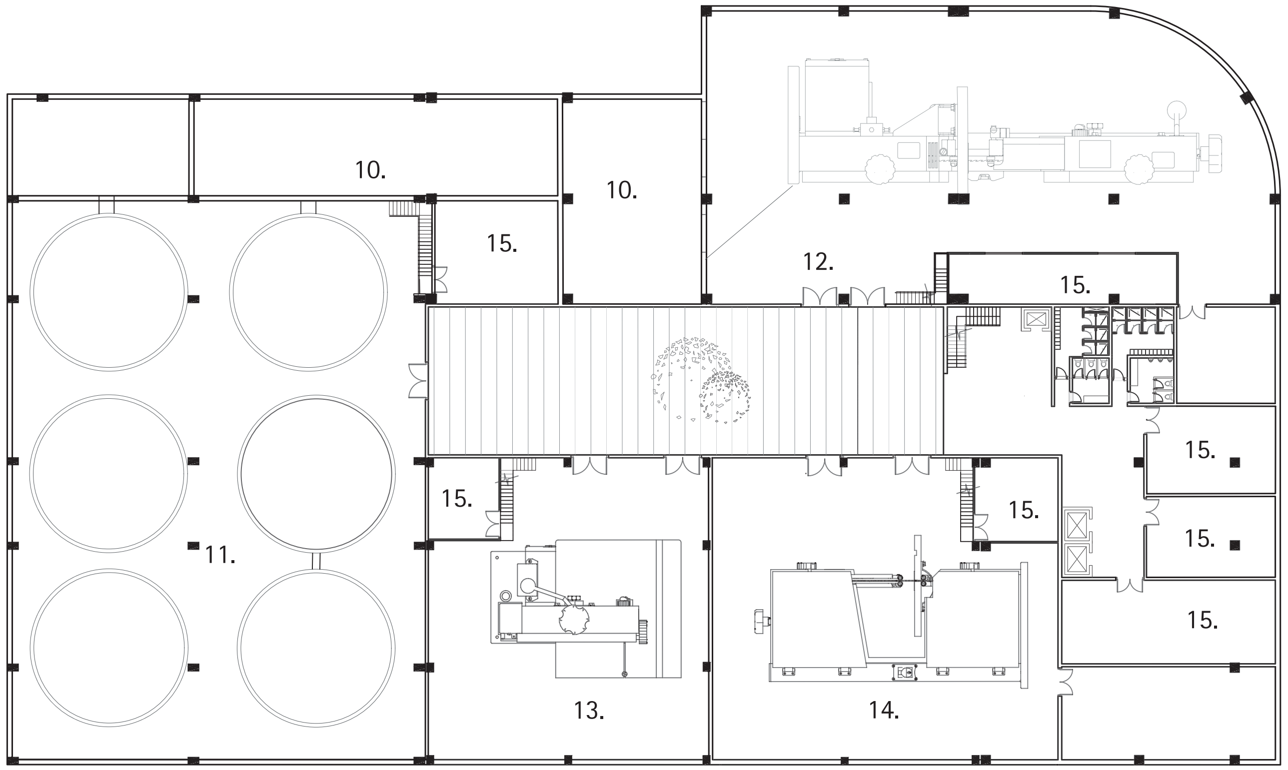
THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

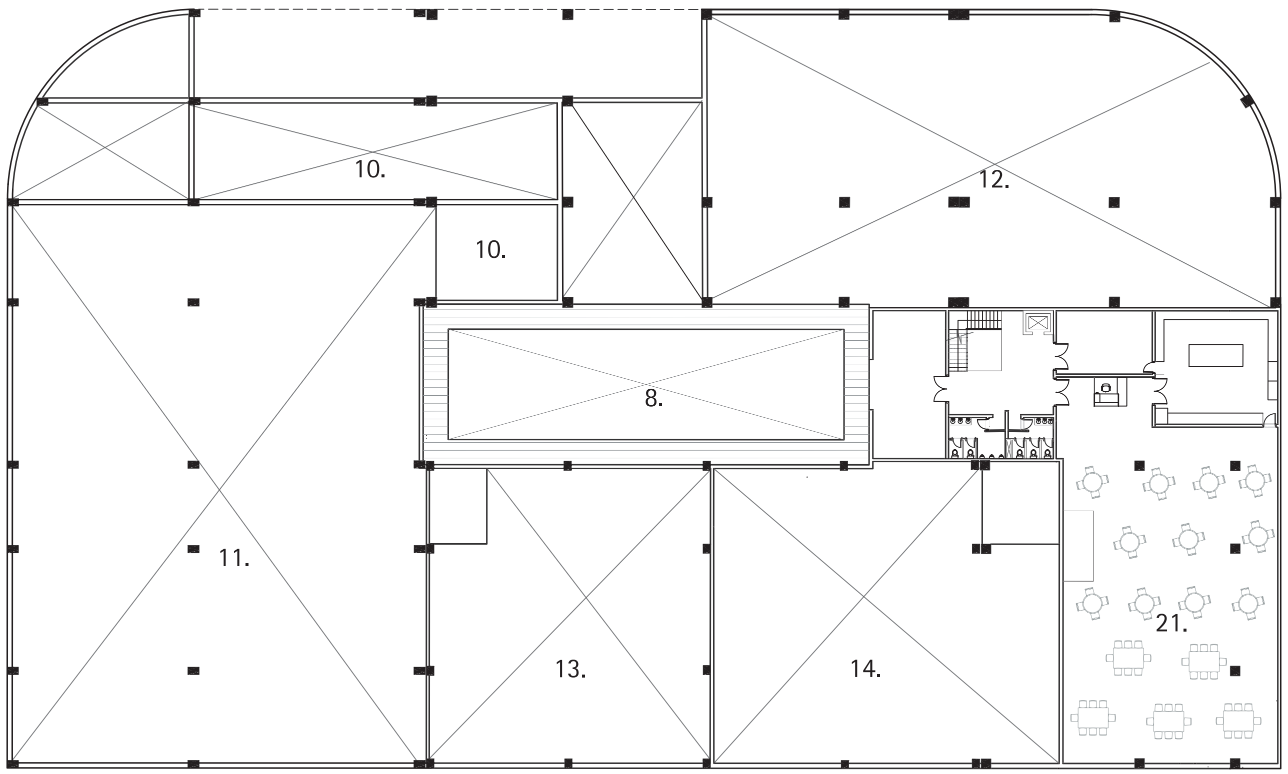
SHEET TITLE:
PUBLIC LEVEL PLAN
(± 6000mm LEVEL PLAN)

SCALE :1:300(IN A1)
DATE :080-01-10

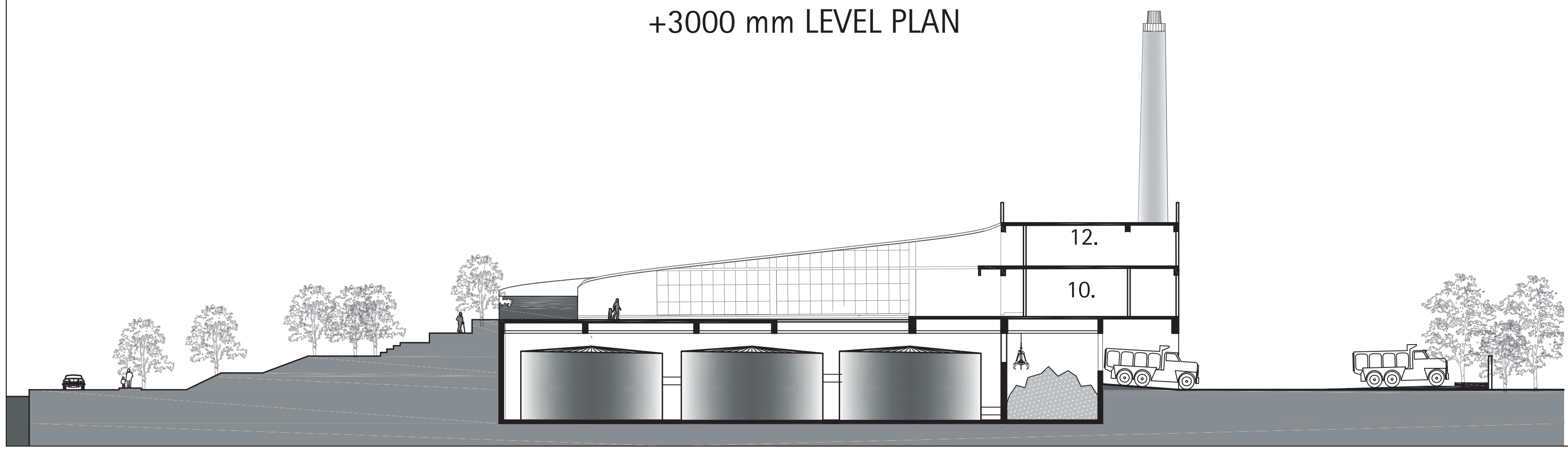
SHEET NO. :AR 10.a

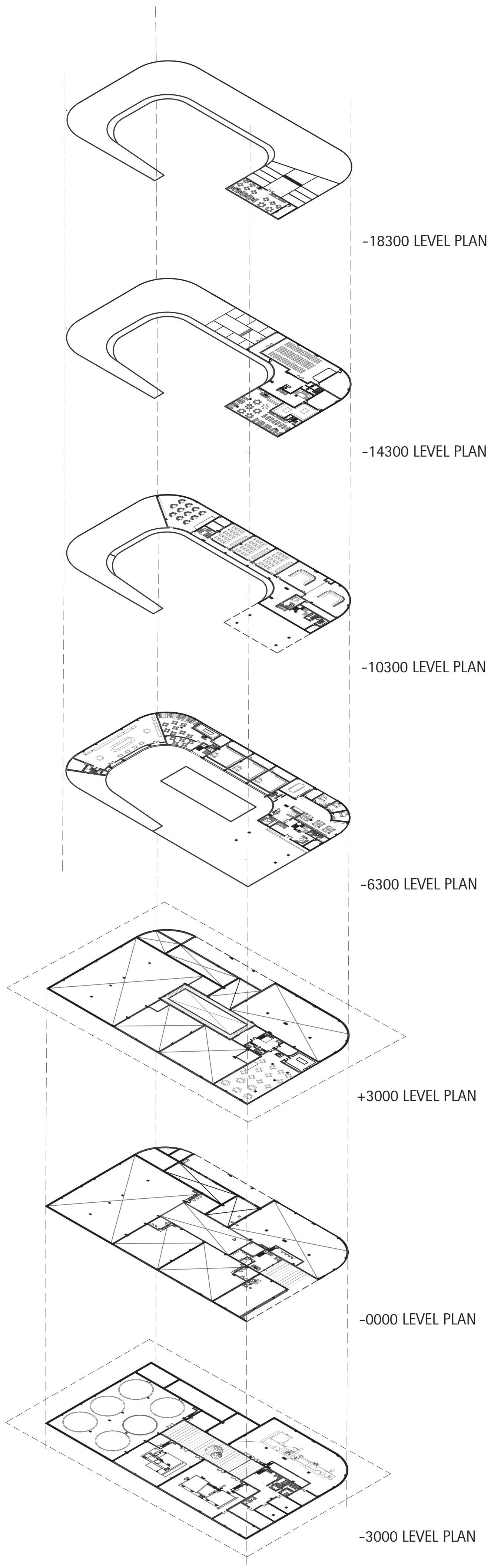


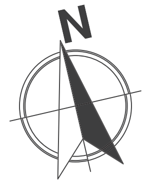
-3000 mm LEVEL PLAN



+3000 mm LEVEL PLAN







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8.COURTYARD
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15.STORAGE
16.RECEPTION/LOBBY
17.STAFF ROOM
18.OFFICE
19.FIRST AID ROOM
20.CONTROL ROOM
21. CANTEEN
22.TRAINING CENTERS
23.CLASSROOMS
24. WORKSHOP STUDIOS
25. CONFERENCE HALL
26.RESTAURANT

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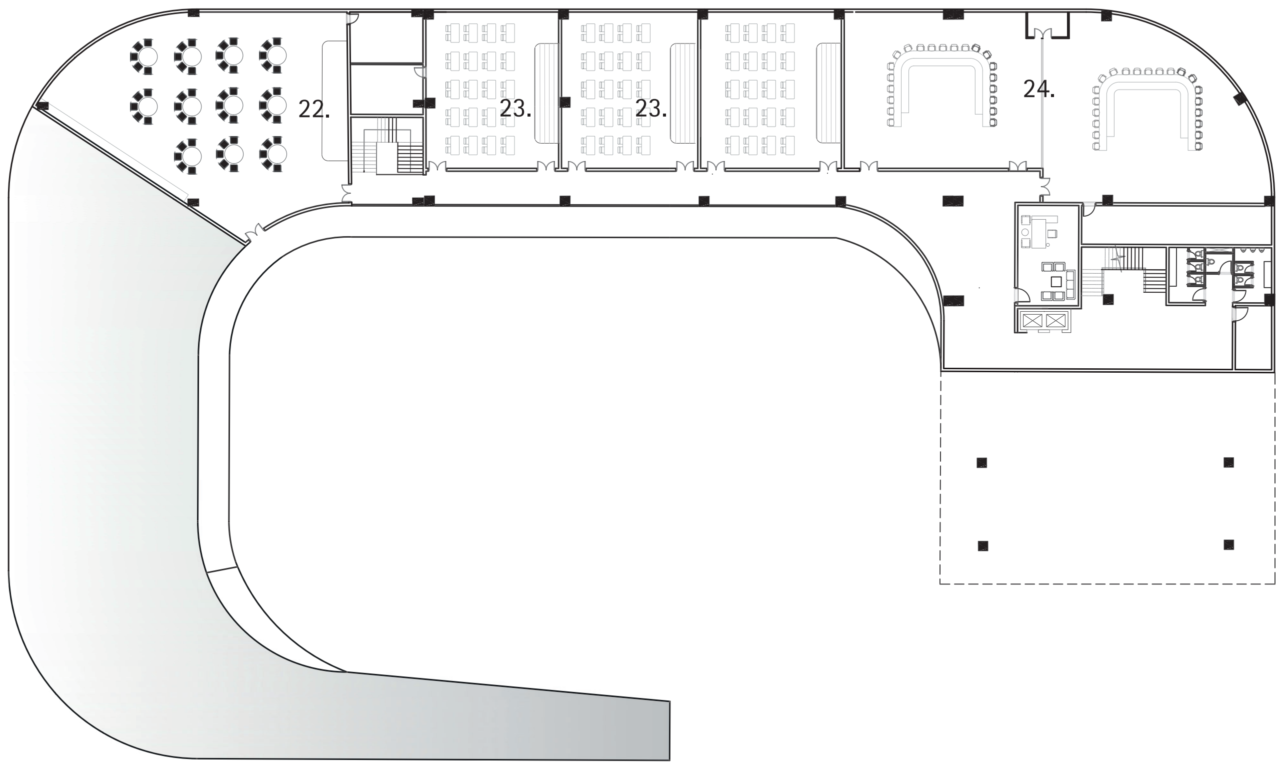
THESIS TITLE:
WASTE RECYCLING CENTER
FOR KATHMANDU METROPOLITAN CITY

THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

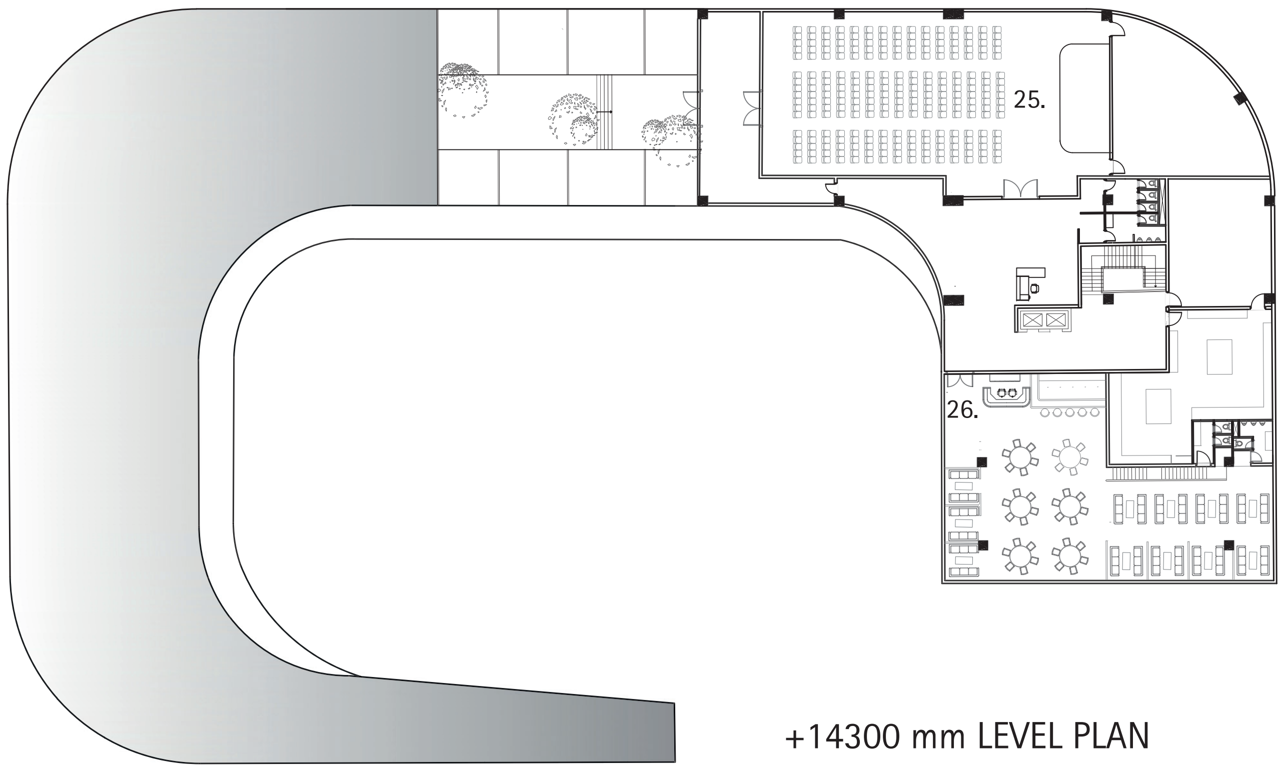
SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
FLOOR PLANS

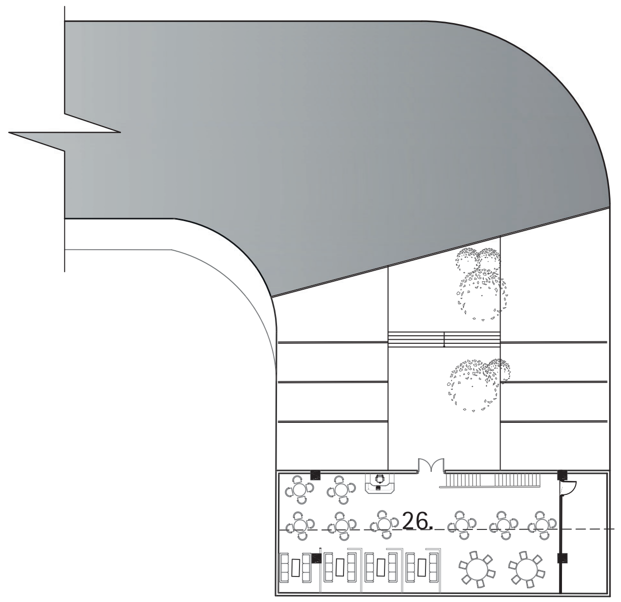
SCALE :1:300(IN A1)
DATE :080-01-10
SHEET NO. :AR 10.b



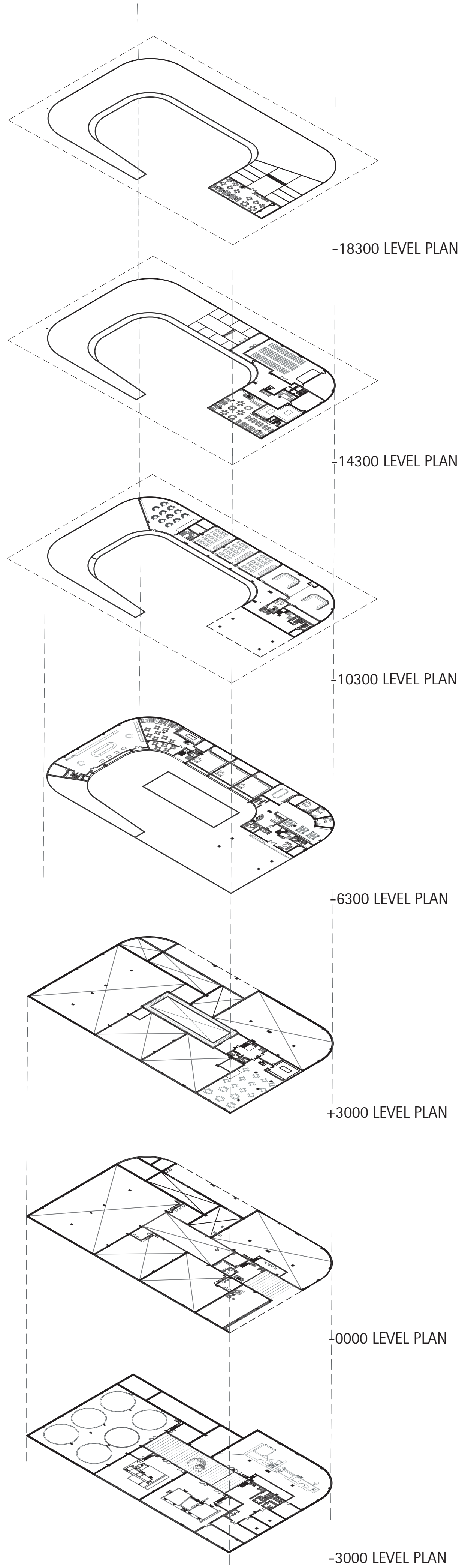
+10300 mm LEVEL PLAN



+14300 mm LEVEL PLAN



+18300 mm LEVEL PLAN



N

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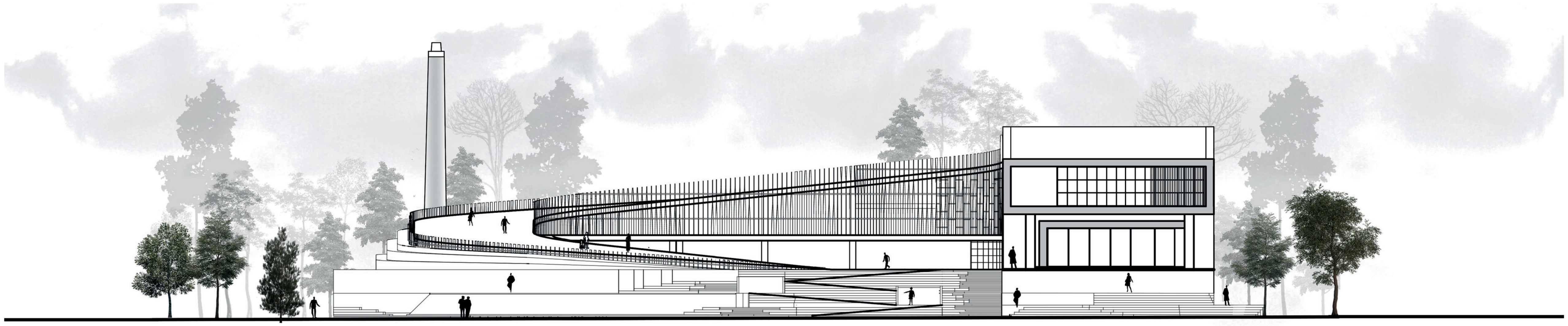
SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

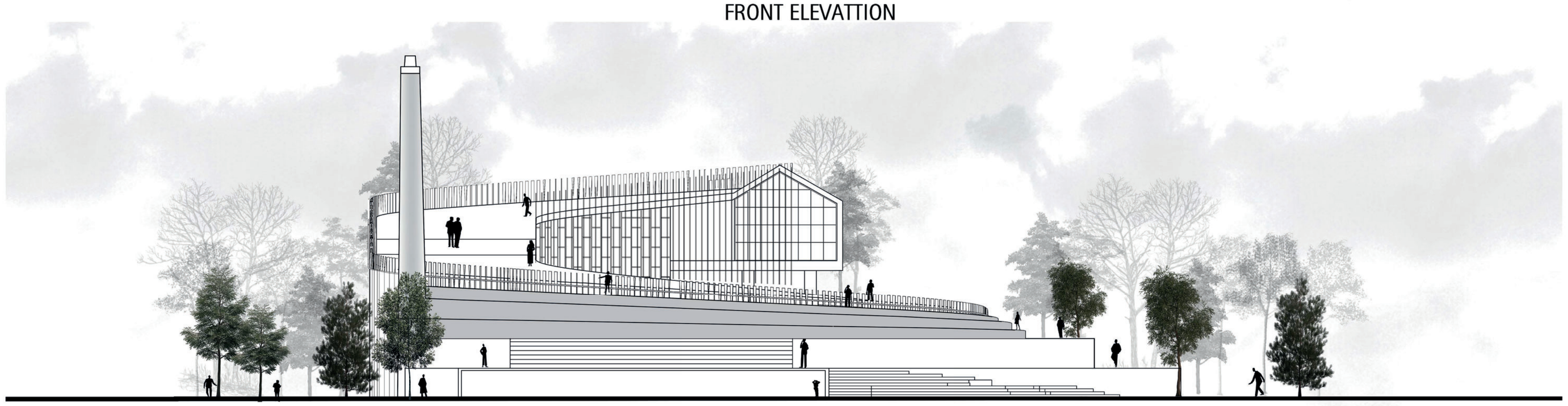
SHEET TITLE:
FLOOR PLANS

SCALE :1:300(IN A1)
DATE :080-01-10

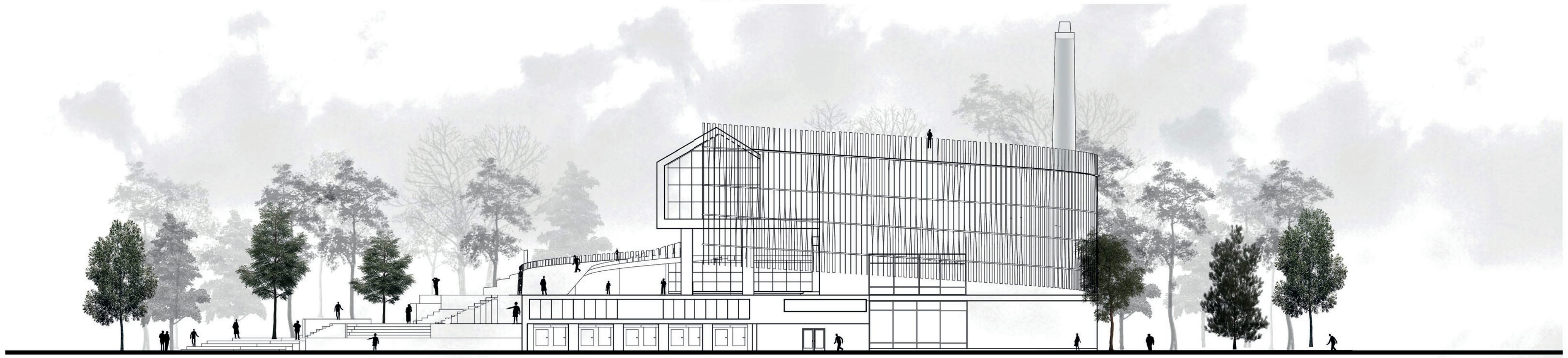
SHEET NO. :AR 10.c



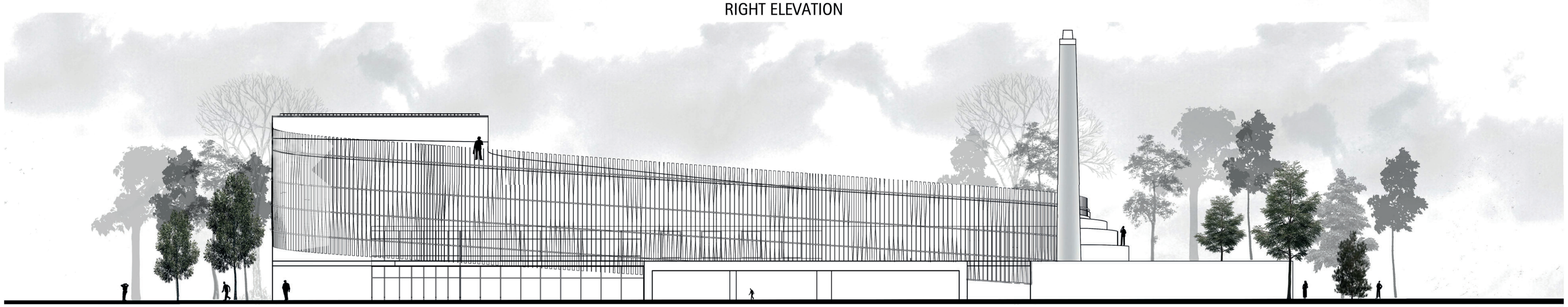
FRONT ELEVATTION



LEFT ELEVATION



RIGHT ELEVATION



BACK ELEVATION

TU, IOE
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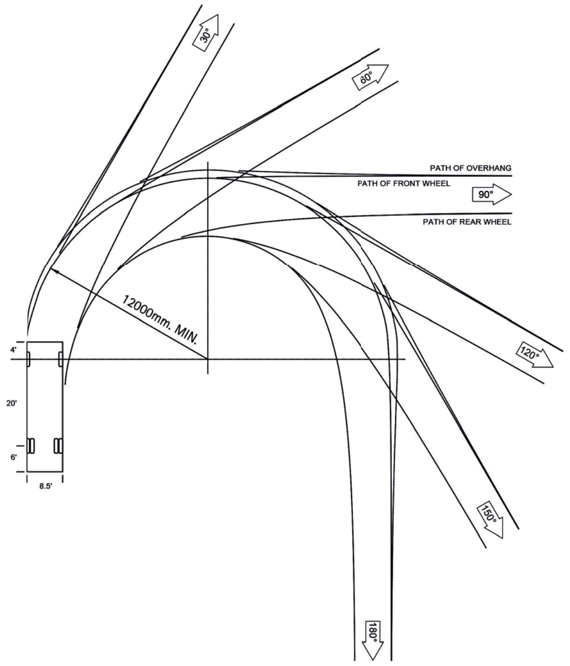
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

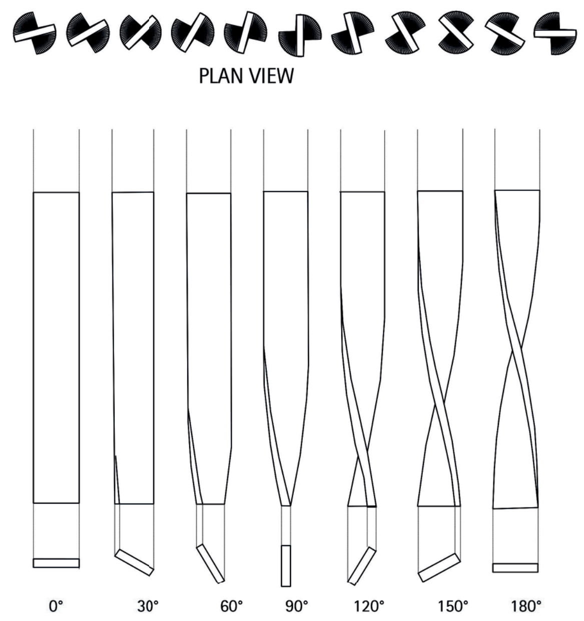
SHEET TITLE:
ELEVATIONS

SCALE :1:300(IN A1)
DATE :080-01-10

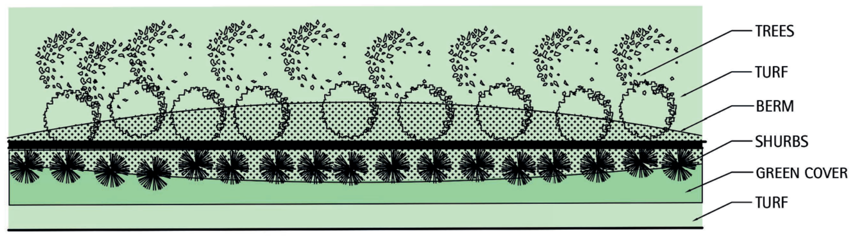
SHEET NO. :AR 12



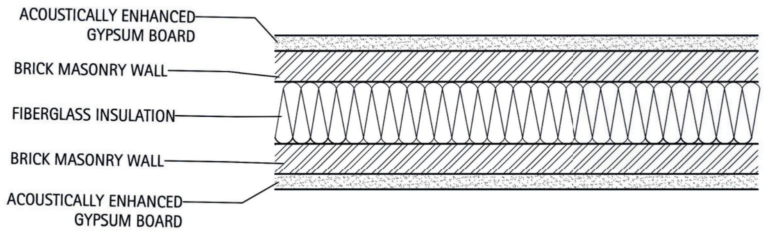
TURNING RADIUS FOR WASTE TRUCK



TWISTED FACDADE SCREEN ELEVATION

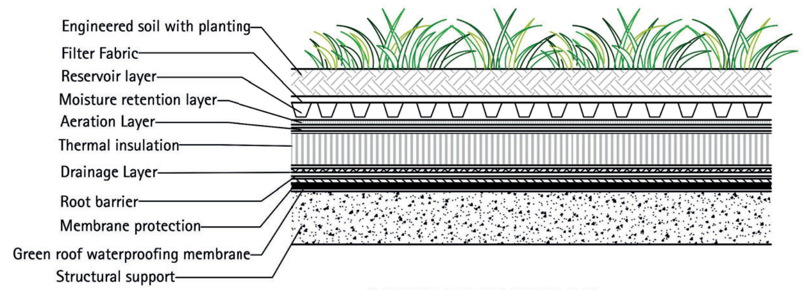


STREET SURFACE

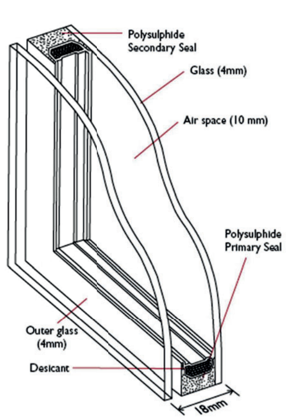


ACOUSTIC INSULATION DETAILS

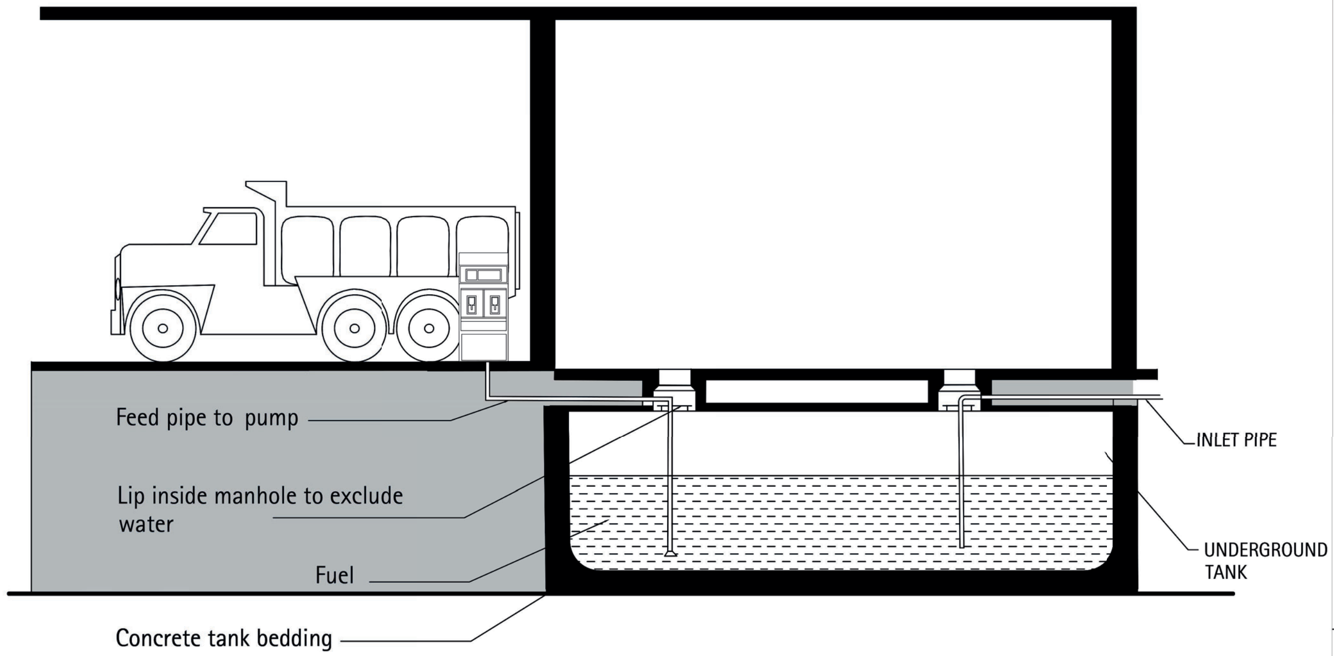
VEGETATIVE EARTH BUFFER



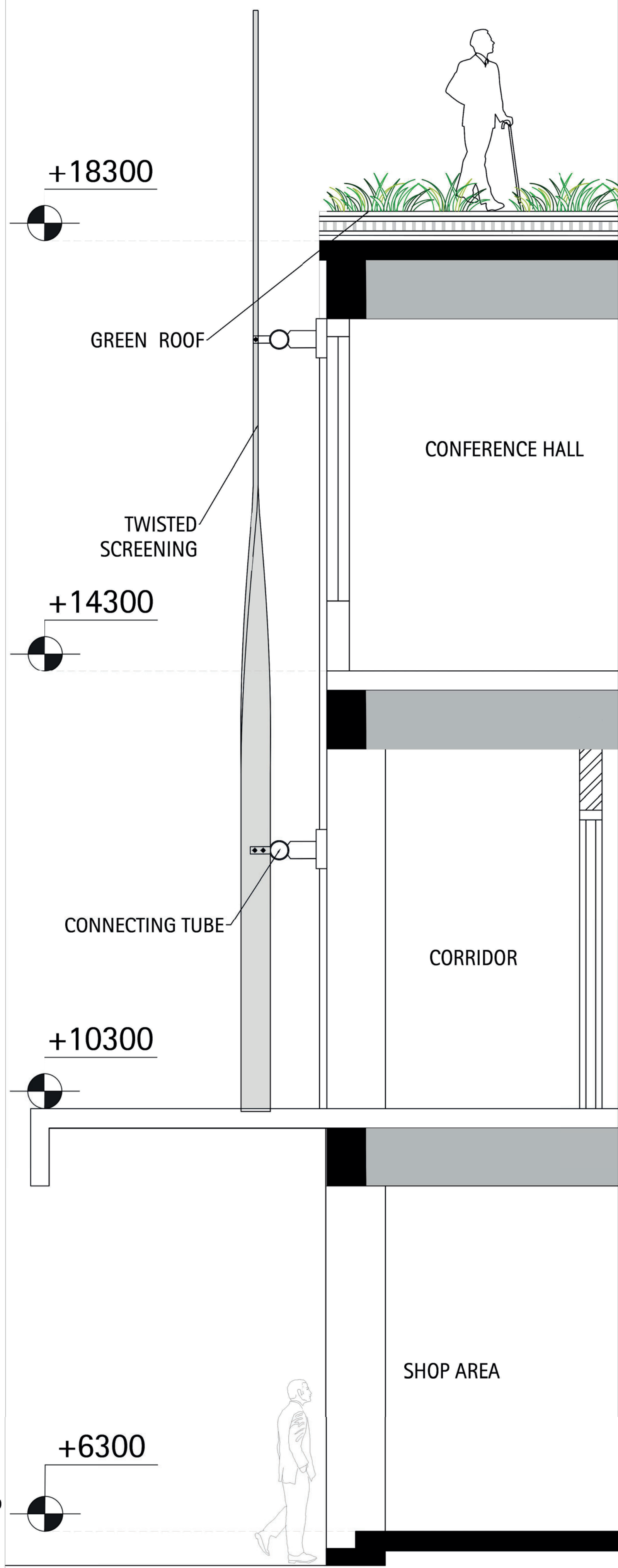
GREEN ROOF DETAILS



DOUBLE GLAZED WINDOW DETAIL



TYPICAL SECTION OF FUEL STATION



TU, IOE
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DEPARTMENT OF ARCHITECTURE
PULCHOWK LALITPUR

THESIS TITLE:
WASTE RECYCLING CENTER
FOR KATHMANDU METROPOLITAN CITY

THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

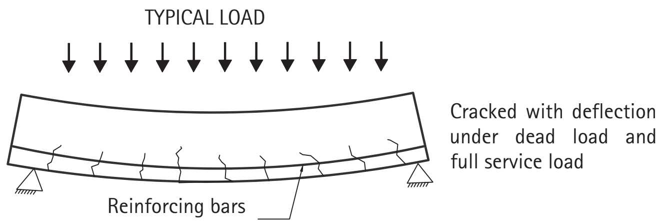
SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
ARCHITECTURAL DETAILS

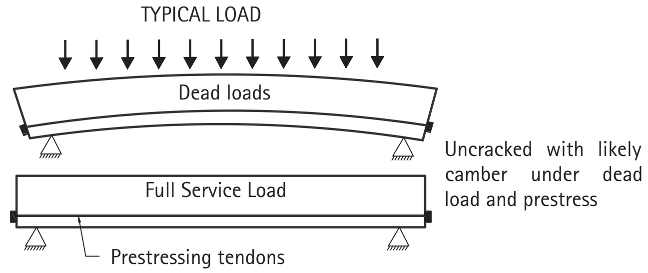
SCALE :
DATE :080-01-10

SHEET NO. :AR-13

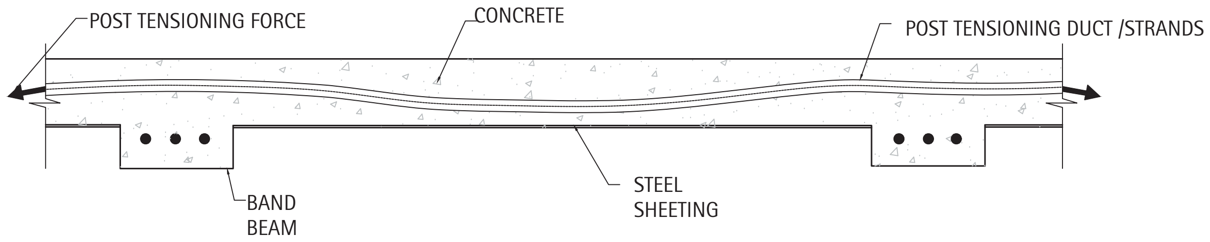
POST-TENSIONING SYSTEM



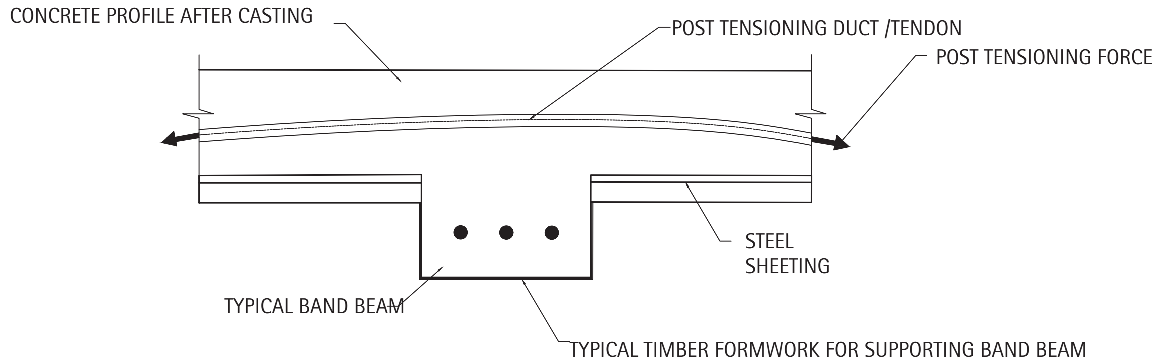
REINFORCED CONCRETE(RC)



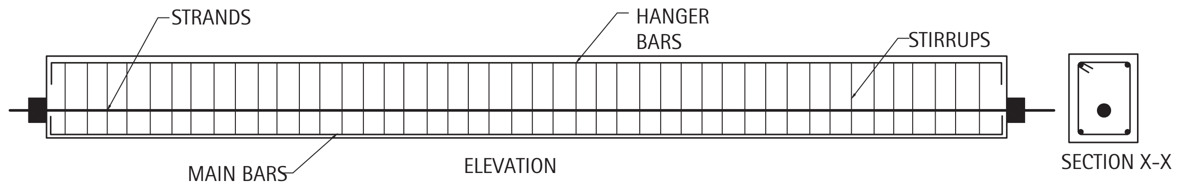
PRESTRESSED CONCRETE(RC)



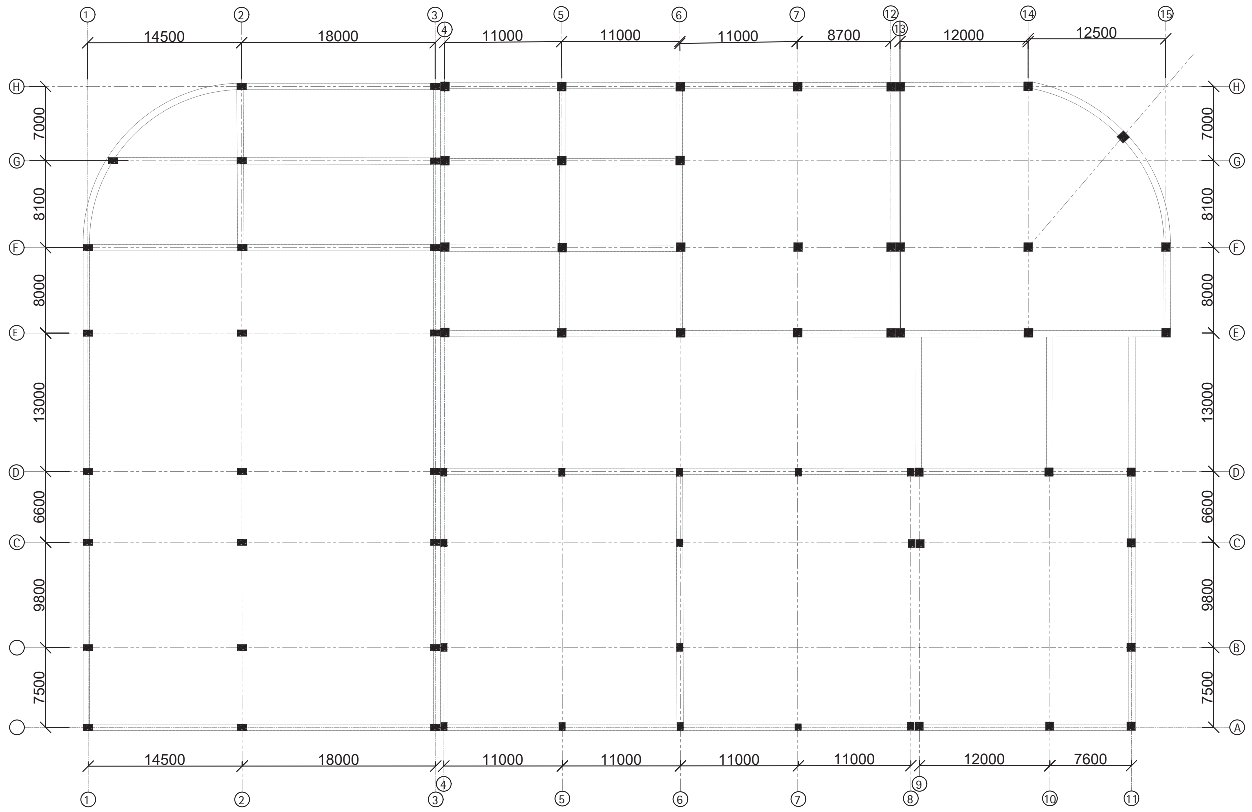
A. TYPICAL ELEVATION OF A POST -TENSIONED COMPOITE SLAB SUPPORTED BY BAND BEAM



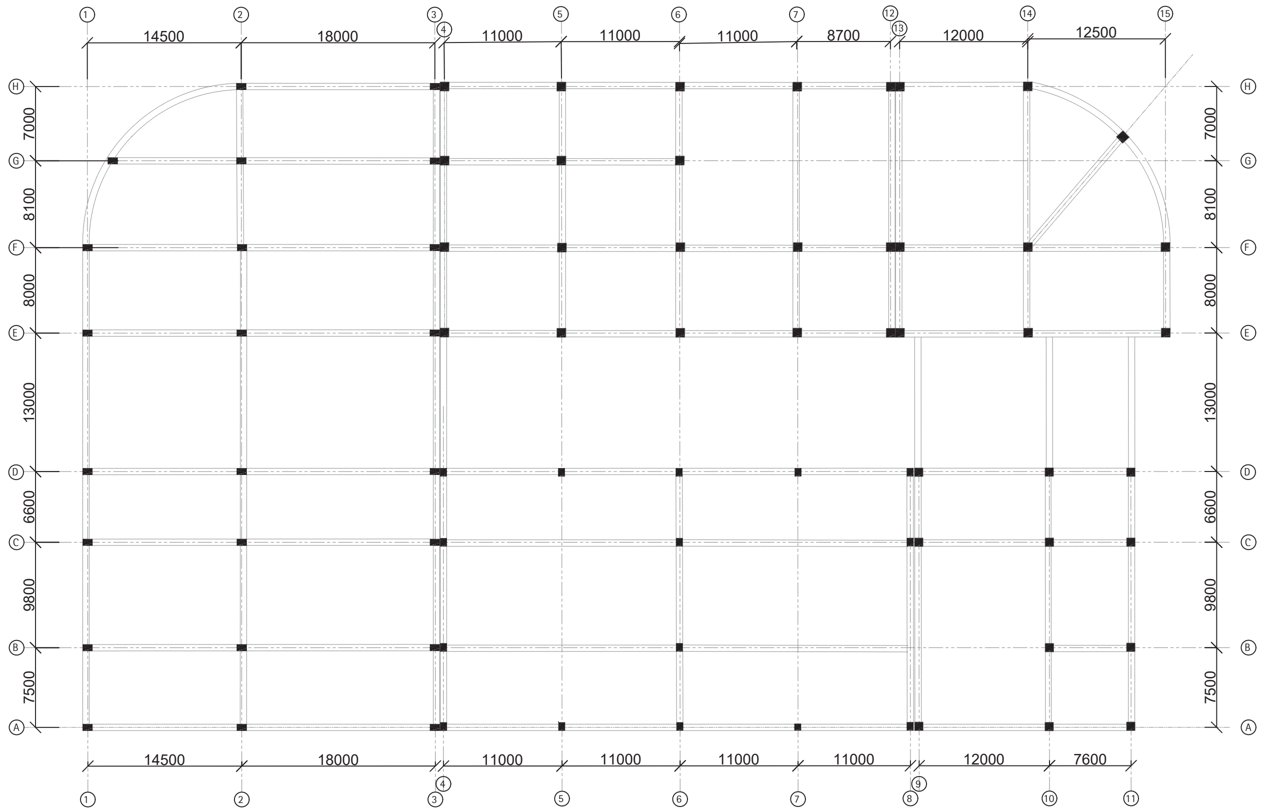
B. TYPICAL CONSTRUCTION DETAIL OF PROFILED STEEL SHEETING BEING SUPPORTED FROM FORMWORK OF BAND BEAM BEFORE CONCRETE POUR



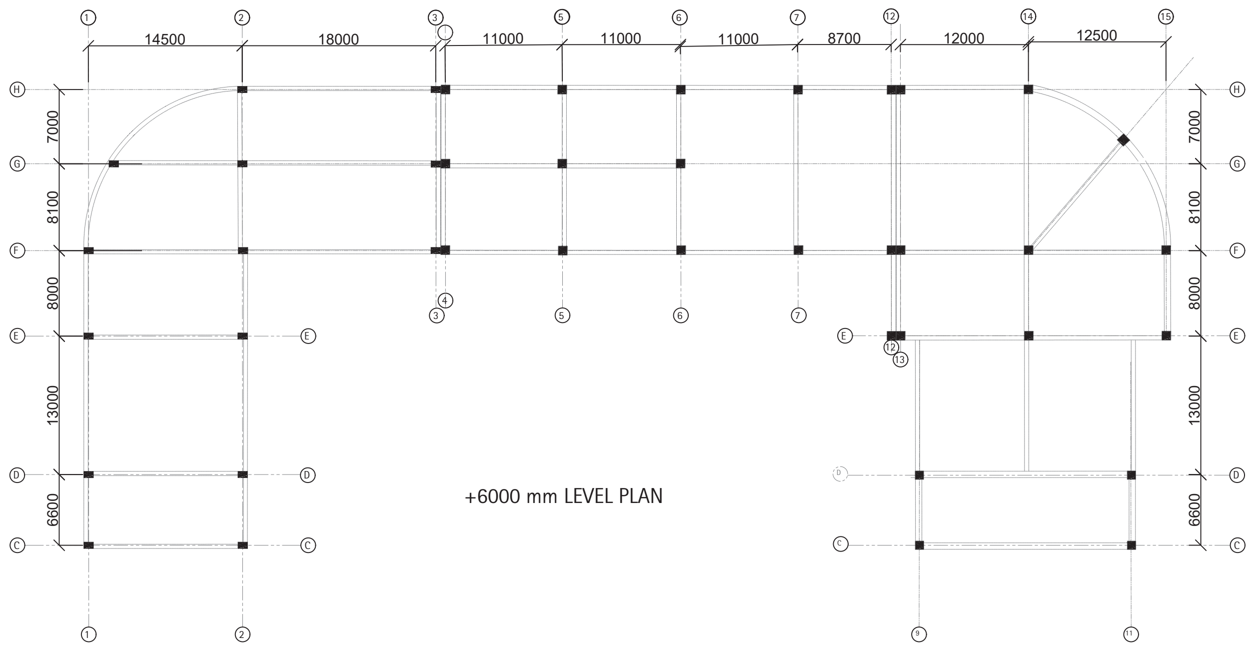
C. TYPICAL DETAILS OF POST TENSIONED BEAM



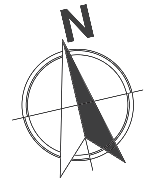
GROUND FLOOR PLAN



+3000 mm LEVEL PLAN



BEAM-COLUMN LAYOUT PLAN



TU, IOE
PULCHOWK CAMPUS
DEPARTMENT OF ARCHITECTURE
PULCHOWK LALITPUR

THESIS TITLE:
WASTE RECYCLING CENTER
FOR KATHMANDU METROPOLITAN CITY

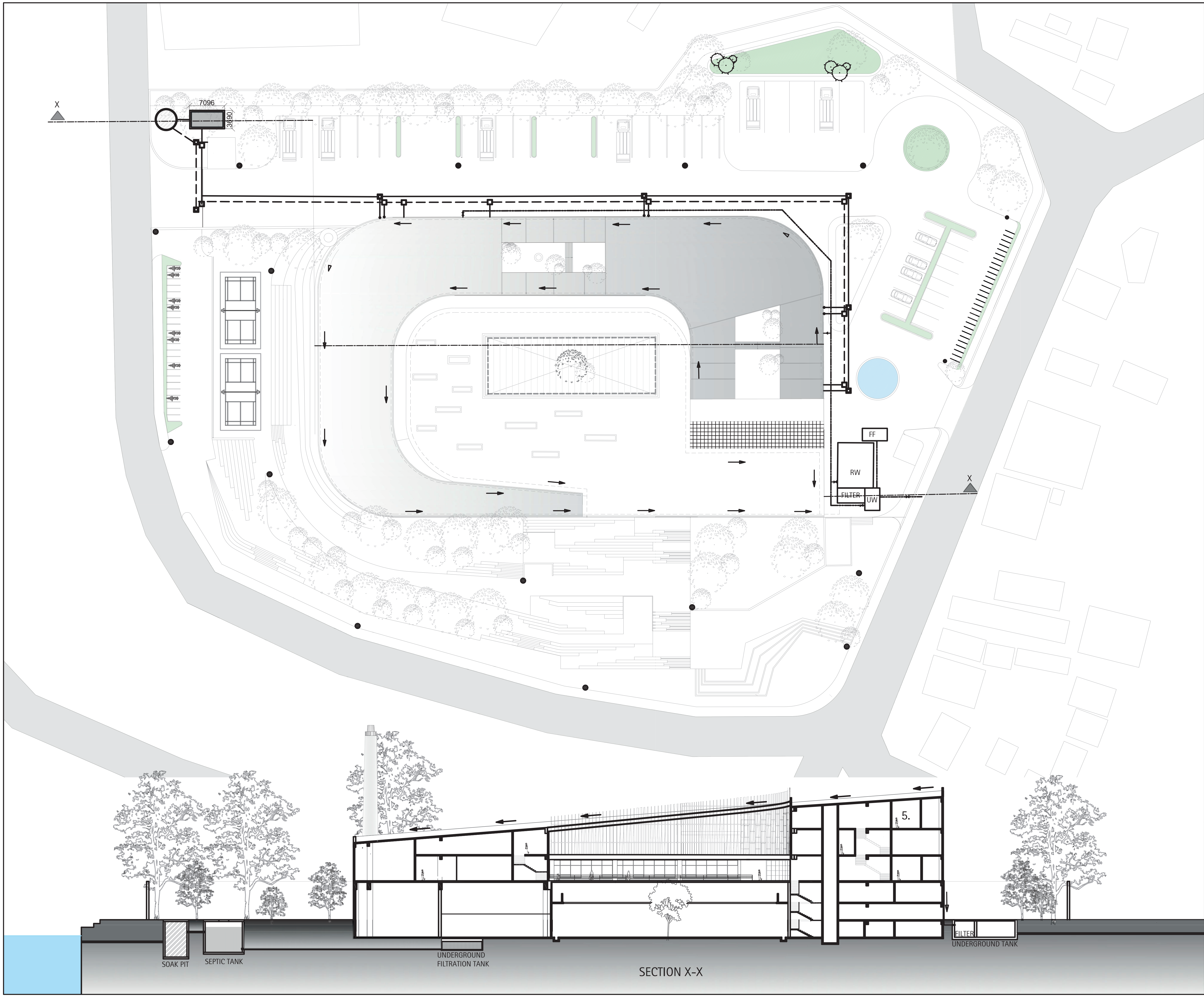
THESIS SUPERVISOR:
ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
STRUCTURE

SCALE :1:300/1:350(IN A1)
DATE :080-01-10

SHEET NO. :ST 01



SECTION X-X

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- PV CELLS

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DEPARTMENT OF ARCHITECTURE
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ASST. PROF. PRAJWAL HADA

SUBMITTED BY:
MANISHA SHRESTHA
074-BAE-218

SHEET TITLE:
SERVICES: SANITARY

SCALE:1:300
DATE :080/01/10

SHEET NO. :SR-01

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