

# Design Concepts of Green and Sustainable Industrial Park

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**Abstract** – A sustainable and green industrial park is an area allotted for industries with initiatives to reduce waste, pollution, share resources (such as materials, water, energy, infrastructure, and natural resources), and help achieve sustainable development, with the intention of improving environmental quality. Our study aims at a design process with a flexible and adaptable layout of the park to maximize use of renewable energy and minimize carbon emissions. The work includes impact studies, waste treatment, sustainable processes like carbon capturing, renewable energy sources, eco-friendly construction materials, rain water harvesting, permeable pavements etc. Here we transform a normal area of land into an efficient and eco-friendly industrial zone. The study can be considered as a general design as the technologies adopted here can be applied irrespective of locality.

**Keywords** – Sustainable, Green, Green building, Recycle, Construction, Industrial park.

## I. INTRODUCTION

An industrial park can be defined as “a large area of land, divided and developed for the use of different firms simultaneously” by sharing resources and common amenities. Various aspects of eco-industrial parks (EIPs) have been widely studied over the past decades. The main objectives of Green Industrial Park include reducing pollution and waste, sharing resources efficiently and minimizing the impacts on the environment.

The basic principle for Green and Sustainable Industrial Park is that the total benefit (improvements to social, economic and environmental impacts) achieved by working cooperatively is higher than working as an individual facility. Green Industrial Parks make the ideal environment for efficiently applying the idea of industrial symbiosis, where a number of industries are clustered in one place to benefit from waste as an input to production. In this assembly, anchor industries appear as well as scavenger industries which ensure that the loop is closed as they function on the by-products of those anchor industries.

Here, we introduce the design of a Green and Sustainable Industrial Park, to produce a flexible and adaptable design for an industrial estate to maximize the use of renewable energy, eco-friendly materials from waste products, and to minimize carbon emissions.

## II. SITE SELECTION

Selection of sites for an industrial park is governed by many considerations. It includes the cost of land, labour, materials, light, power and also the costs of marketing from that place should be estimated. The main thing that is to be considered is access to the site. The site must be easily accessible to airport, seaport, railway station, bus station etc. This helps the easy movement of goods and raw materials from and to the Industrial park. Site selection and development should focus on sustainability. Priority is given to the sites that have the least negative environmental impact, fewest possible threats, requires least extraction of natural resources for the site preparation, construction and operation and those that offer the best quality of life for the chosen processes. The source of availability of raw materials is an important factor in the selection of site for an industry. The land characteristics of the proposed site has to be examined carefully. Since land topography and soil structure may have a pronounced effect on the construction cost. Thus, the geographical location of the site contributes a lot to the success of the industrial venture. Utmost care and judgement are therefore required for the site selection.

## III. LAYOUT & PLANNING

The layout and planning of the park is the most important step in design of an industrial park. The planning must be done very carefully. The area of each plot required must be chosen. The path through which the road passes by must be chosen carefully. The entrance should be mostly

in a straight portion, i.e try to avoid entrance at curves. If there are obstructions like rock or hard strata at straight portions curves can be considered. The road should be in such a way that, it should have minimum grade so that the movement of goods vehicles will be easier. It is mostly based on the type of plot. If the plot is an hilly area this must be considered. The plots must be aligned such that its entrances must be at same gradient to that of road level there. The various steps in layout and planning is:-

### 1. Site Surveying

The survey is done by a total station. It helps to prepare cadastral maps of plot showing the boundaries of the site, levels of land, height difference at different points etc. The contour plan of the plot can be prepared which is necessary for preparing cutting and filling data. It is the main procedure before construction procedure.

### 2. Preparing Drawings

After the survey the drawings of the plot is prepared, The contour drawing and cadastral map is first prepared. The position of road and plots are fixed and reduced levels are decided. This is required to do the calculations of cutting and filling works. After the cutting and filling the plans with necessary details are prepared.

### 3. Design of Amenities and Prepare its drawing

Amenities are important for an Industrial park. More about amenities will be described later.

### 4. Design and Drawings of structures

Structures like retaining walls, drains etc must be designed according to the needs. Retaining wall depends on the height of soil to retain and the type of soil. The data can be identified by the drawings of the plot prepared. Drains are designed based on rainfall and volume of water that is to be carried. These data can be collected using average rainfall of 25 years of the area.

## IV. IMPACT STUDY

Industrialization is important for the economic growth and development of a society. But its various processes can be harmful to the environment. Thus, the very first procedure of designing an Industrial Park is to find how it affects the environment. The Impact study or an Environmental Impact Assessment can be done by checking various parameters. The purpose of preparing EIA is to ensure the decision makers to consider the environmental impacts when deciding whether or not to proceed with a project. It's a tool used to identify the environmental, social and economic impact of a project prior to the decision-making. EIA can also be considered as both science and art, reflecting the technical aspects, such as impact identification and prediction, as well as evaluation, management, and information presentation. If the area of park is less than 10 hectares EIA is not required.

In a typical EIA report, we include the environmental baseline data, that comprises various parameters like location and physiography of the place where the park is planned. Studies on Air quality, Water quality, Noise, Seismicity, Socio-economic study, changes in land pattern, positive and negative environmental impacts that includes the impact on the environment due to the project locations, project design and construction works, operations etc. Environmental management plan, environmental monitoring plan and disaster management plans that include various environmental characteristics are carried out. Ambient noise level in an industrial area is considered as 55dBA during day time and 45dBA during night time. It is found that industries release harmful residues to the environment. Thus, it is necessary to have an EIA for the proposed project. Most of the environmental issues due to the development of an industrial park includes the change in land use pattern, non-renewable resource usage, air pollution, water pollution, soil pollution etc. Thus, while considering sustainable and green development, the main concern should always be to reduce the above-mentioned factors. The methods for this will be discussed further in detail.

## V. AMENITIES

An industrial park should provide basic amenities to the industries and workers cooperating with them. This includes canteen, staff quarters, warehouse, water supply, electricity, security, administrative services, parking, loading and unloading facility etc.

### 1. Canteen

Canteens and Eateries should be provided for bringing good quality and healthier food for the workers and staff in the park. The canteen size should be based on the number of staff working in the park. It must have seats to accommodate all workers. The kitchen size depends on the ratio 60% dining area and 40% kitchen area. The water to the canteen and kitchen should be considered while designing the water tank.

### 2. Staff Quarters

Quarters are provided for workers who wish to stay in the park. The size of the quarters can be based on the position of the workers. The quarters can be of many types, bhk type, dormitory type etc.. The quarters can be provided for families too for administrative officers.

### 3. Warehouse

Common warehouses can be constructed for storing goods produced in the industries. Loading and unloading facility and truck parking facility etc.. should also be provided with it.

### 4. Water Supply

Water is the major need for both industries and workers. Water demand per capita is calculated using average per

capita demand in india and water required for industries is calculated and water required will be the sum of both. Water tank with required capacity is designed. Elevated circular water tanks will be suitable as elevated tanks can give maximum head and circular shape can resist wind load. Water intake can be from wells, rivers, sump etc.

#### 5. Administrative services

Administrative service is the backbone of the park. Proper maintenance, accounts, etc must be kept. An administrative office must be provided for these officers to work for the proper running of the industrial park. The office building must be spacious i.e a minimum of 35 sq feet must be provided for a worker. The size of the building depends on the number of officers. Normally the officers belong to - A manager, maintenance wing, Accounts wing, Finance wing. These are the minimum requirements for an industrial park.

### VI. WASTE TREATMENT

Waste treatments are the activities required to ensure that waste has the least harmful impact on the environment. The adopted methodology for this includes a tertiary treatment process. Generally, the goal of wastewater treatment is to transform the raw sewage into water clean enough to be discharged into a water body without causing harmful environmental or ecological consequences. Sewage treatment includes the combination of physical, chemical, and biological processes to achieve goals such as: 1) to reduce "aesthetic pollution" - smelly organic matter, 2) to kill the pathogenic microorganisms and to remove the toxic wastes, 3) to reduce the organic material or B.O.D., and 4) to remove inorganic nutrients like nitrogen and phosphorus that can cause eutrophication. Sewage treatment plants are not only designed to purify drinking water, but also to reduce the potential of sewage to pollute aquatic ecosystems.

An Effluent Treatment plant can be constructed to treat the effluents from various industries. It includes; (1) First the effluent passed to the screening chamber and then to the grit chamber to remove larger particles if any, (2) Then send to equalization tank – this is done to equalize the flow of water, (3) Flash mixing is then used to mix chemicals to water and mix thoroughly to attract particles and clump them and then flocs are allowed to form in the flocculator, (4) Primary clarifier is the place where the solid particles created from the above process is allowed to settle in the primary clarifier, (5) Aeration tank - the microbial growth in the water is increased by pumping oxygen into it, (6) Secondary Clarifier removes the activated sludge, (7) After these processes, Flash mixing and flocculation is done again (8) Tertiary clarifier is where the final cleaning process is carried out to improve the quality of water, (9) Sand filter and activated carbon filter are used to purify water, (10) the next step includes Chlorine disinfection (11) Clean water is then

discharged to the well or tank for reuse, (12) Sludge collected is then allowed to dry in a sludge drying bed and later it can be transported to the sludge disposal area.

This water treatment method makes the Industrial Park sustainable with water. The process can recycle about 87% of waste water to pure water. This makes the park sustainable for water. Though the method is a bit costly, it is the most efficient method for effluent treatment.

### VII. ENERGY SOURCES

Energy requirement of the park can be fulfilled by using renewable energy sources like wind energy, solar energy etc. Sustainable energy is widely encouraged as it does not harm the environment and is available widely free of cost. The main aim of energy sustainability is using green energy so that the impact on the environment is decreased and moreover if energy is generated in the park itself it can reduce the cost for electricity.

#### 1. Solar Energy

Sun is the primary source of energy. Solar Energy is the most easily available energy. Solar Energy is adaptive to any type of plots. It is the cleanest form of energy and no other transformation of energy is required. Evidence of intensive use of this alternative form of energy source can be seen throughout the globe. Solar energy is trapped using solar panels and stored for use. The solar panels are available in various sizes. The size can be selected in a manner that maximum power can be generated from minimum number of panels. Solar Panels can be provided in the rooftops of buildings. The parking areas can be completely made of solar roofs. The best example for a solar parking area is Cochin International Airport. The excess energy generated can be sent to the grid and it can be retaken whenever needed. The initial investment will be a bit costly but compared to future electricity bill the method will be profitable.

#### 2. Wind Energy

Wind Energy is a clean and renewable source that can be fetched from nature, as it doesn't pollute the air like power plants which rely on chemicals causing human health problems and economic damages. The technology requires a constant wind with a minimum speed of 9 mph. Wind turbines are a source of power generation. In near future, sustainable energy like wind power will become a large industry and fossil fuels will no longer be used again. Wind turbines can be placed at suitable places at suitable heights to fetch energy.

### VIII. SAFETY

Industrial safety is the management of all operations and events within the industry in order to protect its employees and assets by minimizing risks, hazards and accidents. Industrial safety is important as it safeguards the human life that is related to its processes. It ensures a smooth-

running operation that has the best interests of workers, vendors and customers. Common obstacles for industrial safety includes complex safety laws, ergonomic hazards etc. The importance of industrial safety is realized due to the fact that millions of industrial or occupational accidents occur every year resulting in loss of production time. It is therefore essential to identify the causes of industrial accidents and take necessary measures to control or eliminate them. A safe work environment with adequate safeguards promotes an employee to focus on their work with great enthusiasm.

Some measures that can be taken in order ensure safeties are as follows:-

- Keep work areas and emergency exits clear. Each floor of a building should have an emergency exit that leads directly to the outside area in case of emergency. Eg: fire exits etc.
- Inform supervisors about the prevailing unsafe conditions.
- Use the equipment, machines and tools properly.
- Always wear safety equipment (PPE - Personal Protective Equipments).
- Prevent slips and trips by keeping the aisles, stairs etc. clear and free from spills.
- Eliminate fire hazards.
- Take work breaks from time to time.

## IX. AMENITIES

A sustainable industrial park is a community of businesses that are located on a common property in which they seek to achieve enhanced environmental, economic and social performance via managing environmental and resource issues. Such a system is known as industrial symbiosis, by which the companies can gain competitive advantages by the exchange of materials, energy, water and by-products, thereby leading to a sustainable development. The energy ideas and water treatment discussed above are purely sustainable and green. Water sustainability can be obtained by rainwater harvesting. Construction of rain gardens and using permeable pavement in roads helps to harvest rainwater and replenish groundwater too. Permeable pavements are constructed using permeable asphalt concrete and rain gardens are wet spaces created by planting plants like Summersweet, Red osier dogwood, Blue flag iris, Meadow anemone etc, that can grow in sandy soils and can tolerate dry conditions for several weeks in between rains are preferred.

Based on studies, the best method to go green is using green materials for construction. It is a concept which considers the social and environmental impacts of development and thereby introducing renewable or abundantly available resources for the construction processes that are environment-friendly. Green materials are the one which reduces the carbon footprint. The

buildings can be built using recycled materials or materials that are produced from waste products or by-products. GFRG sheets manufactured by FRBL, Kochi Kerala are the best example for recycled building material. The core material of GFRG is phosphogypsum. The raw gypsum is a by-product of FACT acid plant and hence it is a green material. The material is reinforced with glass fibre to provide load bearing capacity. The material is cheap and affordable for construction.

Table I: Characteristics of GFRG panels

Characteristics	GFRG Panel
Construction Technique	Dry Construction
Speed of construction	Faster
Manpower Saving	Less labour usage (Savings of 20% to 30%)
Acoustic	Offer cavity insulation
Fire performance	Fire resistance up to 4 hours
Seismic protection	Ideal for earthquake prone zones
Refurbishment	Can easily be dismantled or altered
Green	Green and recyclable

Sustainable development is the development that meets the needs of the present without compromising the needs of the future. Sustainable development mainly aims at people and their well-being, in a context where the nature-society imbalances can threaten economic and social stability. From the above-mentioned methodologies, we came to the conclusion that development of an industry is possible without harming the environment. It not only saves the environment, but also saves the national budget, time and also helps in the coordination between the natural resources and people, and conserves natural resources for the future.

## X. CONCLUSION

In this study, we came across various sustainable practices like wastewater treatments, rainwater harvesting and rain gardens, and permeable pavements that could help in recycling and conserving the water resources without polluting the available sources. Availability of clean and fresh air is the basic requirement of every living being on the planet. Developers should take at-most care while expelling their smoke residues out of their smoke-stags. Proper screening must be provided to the expelling smoke so that it is deprived of the chemicals and doesn't harm the environment. Usage of renewable resources like wind and solar energy is a giant leap towards the goal of sustainability. This shows the concern of humanity towards the delicate non-renewable resources. Usage of green materials for construction helps in energy conservation, reduced maintenance, lower costs and

greater design flexibility. More than that, it saves the environment from harmful effects of other construction practices. To illustrate, studies have proved that 16% of all the fossil fuels are consumed every year in order to turn those raw materials into construction products. By considering all these facts, we conclude that it is high time for mankind to shift to a new methodology that could create structures using processes that are environmentally responsible and resource-efficient throughout its life-cycle from designing, construction, operation, maintenance, renovation and reconstruction. i.e., We should achieve sustainable development without harming our surroundings.

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