Corrosion Management
(https://corrosion-management.com/)
Volume 34, Issue 01 – 2024
ISSN: 1355-5243
SCOPUS

SPATIAL BLUEPRINTING OF PLAY INFRASTRUCTURE: OPTIMIZING RESOURCES AND SUSTAINABLE CONSTRUCTION METHODOLOGIES

Lekshmi Priya A N
Assistant Professor
Department of Civil Engineering
Younus College of Engineering and Technology
Kollam,Kerala,India.
lakshmipriya11@atomicmail.io

***Abstract*—Modern urban development increasingly seeks outdoor spaces that harmonize aesthetic appeal with ecological sustainability. This paper presents a multi-disciplinary approach to the design and construction of a sustainable amusement park. The research focuses on minimizing natural resource depletion through the integration of Green Building principles and cost-effective engineering strategies. The technical workflow includes site-condition analysis, soil strength assessment, and high-precision surveying via Total Station. The proposed design was developed using AutoCAD, Revit, and Lumion to ensure structural efficiency and environmental compatibility. The findings demonstrate that sustainable design can mitigate the negative environmental footprints of large-scale recreational projects.**

Keywords—Cost-Effective Design; Geotechnical Analysis; Green Building; Sustainable Infrastructure; BIM (Building Information Modeling)

I. INTRODUCTION

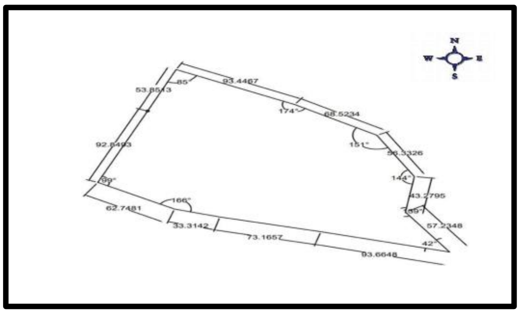
As environmental concerns and resource depletion grow, communities are shifting toward sustainable public spaces. This paper explores the design of a cost-effective amusement park that combines "Green Building" concepts with modern recreation. By using renewable energy and smart waste management to power attractions like water rides and 12D theaters, this paper reduces its impact on nature. Importantly, these sustainable designs also lower long-term water and energy costs, making the project more financially viable. These reduced maintenance costs improve the overall financial health, allowing for better investment in staff and future growth. Using tools like BIM and soil analysis, this research shows that we can build modern, fun spaces that are both affordable and eco-friendly.

II. NEED OF THE STUDY

As cities strive to reduce their carbon footprints, this study proposes an eco-friendly play infrastructure at Kollam designed to support healthy development and improve community lifestyles. This work integrates sustainable infrastructure with a wide range of amenities, including pavilions and event spaces, to create an engaging and environmentally responsible recreational destination for all ages.

III. SITE SURVEY AND ANALYSIS

The survey of the park provides a comprehensive understanding of existing onsite structures, which is essential for developing an accurate master plan. Covering an area of approximately 8 acres (800.073 cents), the site data was used to generate a precise land sketch and boundary map using AutoCAD software. This digital representation serves as the technical foundation for all subsequent design and engineering phases of the work.



The data derived from the experimental procedures, along with the corresponding analytical inferences, are consolidated in the table below.

Slno	ExperimentsConducted	Results	Inference
1	Specific gravity test	Specific gravity = 2.59	Range : 2.48 - 2.8
2	Compaction test	Optimum moisture content = 12 % Maximum dry density = 1.9 g/cm³ Void ratio at maximum = 0.394 dry density	Range: 12% - 20% Range: 1.4 – 1.9 g/cm³ Range : 0.18 – 0.6
3	Field density test	Field density = 1.44 g/cm³	Range= 1.2g/cm³- 1.7g/cm³

TABLE I. EXPERIMENTAL RESULTS

Corrosion Management ISSN: 1355-5243
(https://corrosion-management.com/)
Volume 34, Issue 01 – 2024
SCOPUS

IV. DESIGN

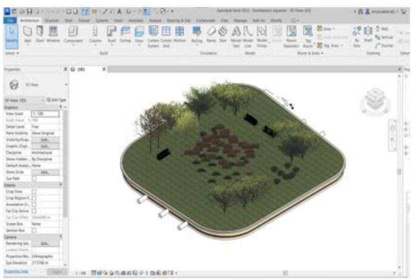
A. BIORETENTION

The bioretention system is engineered with a four-tier profile consisting of a vegetation layer (45 cm), a filtration layer (60 cm), an earth layer (30 cm), and a gravel drainage base (30 cm). To optimize pollutant removal and drainage, the design utilizes a cost-effective blend of organic soils and amendments such as biochar, coconut husk, and water treatment residue. Stormwater runoff is initially filtered through a sand bed to reduce velocity before infiltrating the specialized planting media, where it is distributed evenly across the ponding area. Over several days, the captured water gradually exfiltrates from the bioretention zone into the natural subsoil, ensuring efficient groundwater recharge and high-quality filtration.

FIG 1. IMAGE OF BIORETENTION

The integration of arboreal and vegetative layers within the park serves as a primary driver for microclimate stabilization. By facilitating robust evapotranspiration and evaporative cooling cycles, the greenery actively moderates the ambient thermal environment, significantly mitigating localized heat accumulation. This biological cooling effect is complemented by a strategic approach to hydrological management.

Recognizing that urban stormwater runoff serves as a primary vector for anthropogenic pollutants specifically nitrogenous compounds, phosphorus, and various heavy metals the work incorporates an engineered bioretention framework. This system is designed to intercept and sequester these contaminants, preventing the degradation of the soil matrix and the underlying groundwater table. To ensure spatial accuracy and functional efficiency, the bioretention infrastructure was meticulously modelled using Revit (BIM) software, as illustrated in the accompanying figures. This digital integration allows for a precise intersection between natural filtration processes and engineered drainage solutions, ensuring long-term



ecological resilience.

FIG 2. DESIGN OF BIORETENTION

The primary intention is to construct a cost-effective bioretention system that enhances the sustainability and climate resilience of urban drainage infrastructure. Furthermore, ongoing research is focused on identifying robust floral and arboreal species capable of thriving in extreme climatic conditions to ensure the long-term ecological stability of the site.

B. KINETIC FOOTFALL

To generate clean electricity, the Pavegen system was integrated into the *352 sq m* turf, entrance, and jogging track to capture kinetic energy from human footfall. This sustainable energy is harvested through human movement and stored in a specialized generator room, providing a resource-efficient power source for the park's facilities.

FIG 3. IMAGE OF KINETIC FOOTFALL

C. SOLAR PANELS

To maximize renewable energy use, approximately 90 solar photovoltaic panels were installed on building rooftops, capitalizing on Kollam’s average of 5–6 peak sun hours per day. Each panel has a rated capacity of 445 W, contributing to a total plant output designed to provide a clean alternative to fossil-fuel-based electricity. By converting direct sunlight into usable power, this system eliminates harmful emissions while accounting for local geographic and weather variables to ensure consistent efficiency. This implementation demonstrates a commitment to sustainable infrastructure by utilizing an unlimited natural resource to meet the park's energy demands.

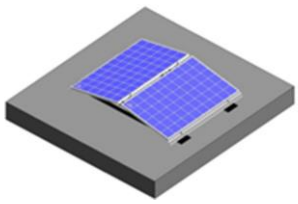


FIG 3. IMAGE OF SOLAR PANEL

D. RAIN WATER HARVESTING SYSTEM

Kollam district receives moderate annual precipitation, though seasonal shifts can lead to unexpectedly high rainfall volumes during specific months.

DISTRICT-WISE RAINFALL DISTRIBUTION

		Day :08-05-2023				Period:01-03-2023 To 08-05-2023			
S NO	MET. SUBDIVISION/UT/STATE/DISTRICT	ACTUAL (mm)	NORMAL (mm)	%DEP.	CAT.	ACTUAL (mm)	NORMAL (mm)	% DEP.	CAT.
1	BANGALORE RURAL	5.4	2.9	86%	LE	65.2	68.6	-5%	N
2	BANGLORE URBAN	3.5	2.2	61%	LE	125.5	74.8	68%	LE
3	BELLARY	0.0	1.4	-100%	NR	88.8	36.3	144%	LE
4	CHAMARAJANAGAR	0.0	2.5	-100%	NR	155.7	112.4	38%	E
5	CHIKBALLAPUR	7.0	2.2	218%	LE	116.7	49.1	138%	LE
6	CHIKMAGALUR	2.7	2.1	28%	E	56.9	94.1	-40%	D
7	CHITRADURGA	1.4	1.2	17%	N	44.2	49.8	-11%	N
8	DAVANGERE	0.0	1.6	-100%	NR	24.2	50.7	-52%	D
9	HASSAN	0.1	1.7	-92%	LD	63.3	92.7	-32%	D
10	KODAGU	0.0	3.5	-100%	NR	66.6	139.3	-52%	D
11	KOLAR	6.8	2.7	152%	LE	133.7	60.3	122%	LE
12	MANDHYA	0.0	1.9	-100%	NR	86.8	85.1	2%	N
13	MYSORE	3.3	2.5	32%	E	133.4	105.6	26%	E
14	RAMNAGAR	0.1	1.7	-92%	LD	149.8	90.3	66%	LE
15	SHIMOGA	0.0	1.8	-100%	NR	27.9	56.7	-51%	D
16	TUMKUR	0.8	1.9	-61%	LD	99.7	59.6	67%	LE
17	VIJAYANAGARA	0.4	1.5	-76%	LD	25.6	38.4	-33%	D
	SUBDIVISION : KERALA & MAHE	0.6	7.9	-93%	LD	164.3	185.2	-11%	N
1	ALAPPUZHA	5.3	9.2	-42%	D	198.8	225.8	-12%	N
2	ERNAKULAM	0.1	9.4	-99%	LD	191.9	194.8	-1%	N
3	IDUKKI	1.9	8.7	-79%	LD	295.1	251.7	17%	N
4	KANNUR	0.0	6.6	-100%	NR	11.1	96.4	-88%	LD
5	KASARGOD	0.5	5.2	-90%	LD	14.5	81.2	-82%	LD
6	KOLLAM	0.0	7.2	-100%	NR	214.3	249.0	-14%	N
7	KOTTYAM	1.2	10.5	-89%	LD	313.0	243.6	28%	E
8	KOZIKOD	0.1	7.9	-99%	LD	27.1	141.9	-81%	LD
9	MAHE	0.0	6.9	-100%	NR	7.4	107.5	-93%	LD

FIG 4. DISTRICT WISE RAINFALL DISTRIBUTION

Climatic data for the region indicates an average annual precipitation of 1634 mm (64.3 inches), with significant seasonal variation between the wettest month, October (275 mm), and the driest, January (15 mm). To manage these volumes, the proposed water harvesting system is engineered with a total storage capacity of 2.154 cubic m. This design ensures the efficient collection and retention of rainfall to support the park's water requirements throughout the year.

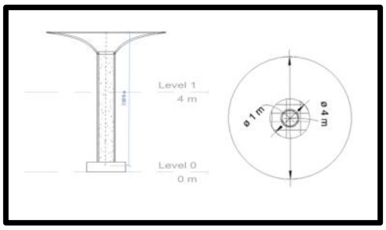


FIG 5. RAIN WATER HARVESTING SYSTEM

A chemical treatment tank was incorporated into the design to ensure that harvested rainwater remains disinfected and safe for use. Decontamination is achieved through chlorination using commercially available agents such as bleaching powder or chlorine tablets. Specifically, a standard 0.5g chlorine tablet is utilized for every 20 liters of water, providing an efficient and accessible method for maintaining water quality within the storage system.

E. DESIGN OF 12D THEATRE

The proposed 12D theater is designed with a 16-person seating capacity and is constructed using eco-friendly, budget-conscious materials such as reclaimed steel, recycled timber, and rammed earth. To ensure high-quality acoustics, the structure incorporates sustainable sound-absorbing elements, including mineral or glass wool derived from synthetic fibers. By utilizing plant-based rigid foam and other low-impact resources, the building achieves both environmental responsibility and cost efficiency. Detailed dimensions and the structural layout of the theater are illustrated in the figure below.

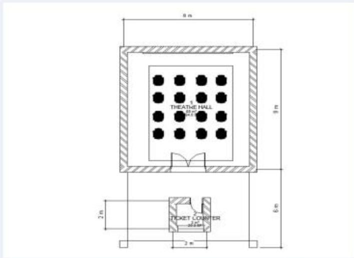


FIG 6. IMAGE OF 12D THEATRE

F. FIXED DOME TYPE BIOGAS PLANT

To implement a circular waste-to-energy strategy, the park's proposed culinary facilities will channel organic residues into a localized anaerobic digestion system to produce biogas. This renewable fuel, primarily a combination of methane and carbon dioxide, is synthesized through the metabolic activity of methanogens and sulphate-reducing bacteria within an oxygen-free environment. For this work, a fixed-dome biogas plant was engineered, featuring a rigid, non-movable gas storage space with an external diameter of 4m and an internal diameter of 2m. Given that internal gas pressure scales with the volume of stored fuel, the digester's capacity is strategically capped at 20 cubic meter to maintain structural safety. The system utilizes a displacement pit (compensation tank) to manage hydraulic levels as gas accumulates in the upper dome, while external pressure regulators are integrated to ensure a steady supply for high-demand applications, such as gas engines. By converting food and green waste into a functional energy asset, this fixed-dome infrastructure provides a durable, low-maintenance solution for onsite resource recovery.

The architectural and functional framework of the proposed biogas facility is defined by three primary technical segments:

- Feedstock Reception and Preparation: This initial stage serves as the staging ground where organic biomass is collected and processed for digestion. Since the fermentation kinetics differ significantly across various organic substrates, the duration of the gasification cycle is determined by the specific composition of the raw materials. In professional applications, mechanical or thermal pre-treatment protocols may be utilized to optimize the decomposition rate and maximize the total volumetric yield of gas.
- The Anaerobic Digestion Chamber: Central to the system is a hermetically sealed, waterproof vault designed to house the biochemical reaction. Once the biomass is introduced, internal mechanical agitators are employed to periodically stir the mixture. This agitation is critical for ensuring a uniform temperature, preventing the accumulation of floating scum layers, and facilitating the efficient release of trapped gas bubbles from the sludge.

Corrosion Management ISSN: 1355-5243
(https://corrosion-management.com/)
Volume 34, Issue 01 – 2024
SCOPUS

- Gaseous Storage and Distribution: The final component is a specialized gas holder—ideally constructed from high-grade steel to ensure an airtight seal—which captures the vapors released during the fermentation process. Equipped with a dedicated outlet manifold, this unit regulates the flow of biogas as it is extracted from the system to be utilized as a sustainable fuel source for thermal heating or electrical power generation.

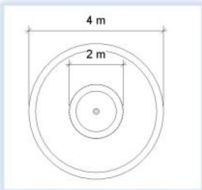


FIG 7. IMAGE OF DIMENSIONS OF BIOGAS PLANT

G. SWIMMING POOL WITH WATER TREATMENT SYSTEM

Our design features a multi-sectional swimming pool tailored for diverse age groups and genders, incorporating a specialized safety system for pediatric protection. To maintain high water quality, we integrated a high-performance purification system utilizing steam-activated carbon columns, which effectively sequester dissolved organic matter and eliminate odors.
This process is critical for mitigating the formation of harmful disinfection byproducts, such as carcinogenic trihalomethanes and chloramines, which arise from the reaction between chlorine and organic pollutants. By utilizing a specific grain size distribution in the form of granules or extrudates, the activated carbon achieves deep-bed penetration within the filtration stages, extending the system's operational lifespan. This optimized configuration ensures the simultaneous adsorption of halogenated organic compounds (AOX) and the chemical degradation of bound chlorine. Consequently, the integration of this Revit-modeled treatment cycle provides a medically safe, technologically advanced aquatic environment that exceeds standard filtration capabilities.

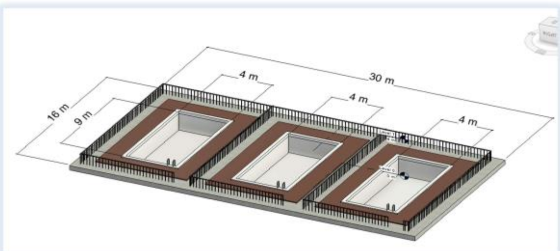
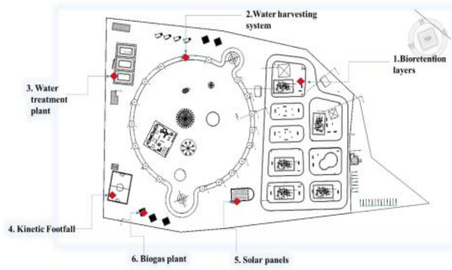


FIG 8. IMAGE OF DESIGN OF THE SWIMMING POOL

FIG 9. IMAGE OF DESIGN OF THE WATER PURIFIER

FIG 10. IMAGE OF LAYOUT OF PARK



V. CONCLUSION

A preliminary assessment of the existing children's park revealed significant hygiene and waste management deficiencies,whichthisredesignaddresses through modernized disposal techniques and sustainable infrastructure. Using a site area of approximately 8 acres determined via georeferenced data, the land's geometry was analysed to optimize the layout. Physical site investigations, including specific gravity, compaction, and field density tests, confirmed that the soil properties are structurally sound for the proposed construction.

The master plan, developed using Revit software, integrates advanced green technologies such as bioretention systems, kinetic footfall power generation, and activated carbon filtration, alongside 16-seat 12D theater. The structural framework prioritizes modular construction and low-carbon materials like hempcrete, ashcrete, and rammed earth to minimize environmental impact. This cost-efficient development serves as a model for community-centric design focused on natural resource conservation and enhanced quality of life.

REFERENCES

[1] Abdellah Harady. (2019). "*Sustainable Park Landscaping as an Approach for the Development of the Built Environment: Review and Employment*" International journal of environmental science and sustainable development,65(5),458-478.

[2] Begum, N. Narayana, J., & SL, A. K. (2010). "*Land Use/Land Cover Changes in the Catchment of Water Bodies in and Around Davangere City, Karnataka,"* International Journal of Ecology and Environmental Sciences, 36(4), 277- 280

[3] Brown and Kuemmerle (2015). "Conversion of open space for utility purpose**".**International Journal of Engineering research and Technology.

[4] Bushra Praveen (2017). "*Monitoring and Assesment of Landslide from Agastamuni to Sonprayag,".* International Journal of Recent Research in Social Sciences and Humanities (IJRRSSH), 4(2), pp. 92-118

[5] Ding, J, Jiang, J, Fu, L, Liu, Q, Peng, Q & Kang, M. (2015) "Impacts of Land Use on Surface Water Quality in a Subtropical River Basin: A Case Study of the Dongjiang River Basin, Southeastern China". Journal Of Water, 7, 4427- 4445

[6] Galen Crans. (2004) "Defining the Sustainable Park: A Fifth Model for Urban Parks"; Research Gate,25(4),87-546.

[7] Javad A and Khan **I** (2015). "Analysis of the use permitted and uses prohibited by the government". Land use Training and resources.

[8] Javed A, Khan I **(**2012)." Land use/land cover change due to mining activities in Singrauli industrial belt, Madhya Pradesh using remote sensing and GIS", Journal of Environmental Research and Development Vol, 6(3A)