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PROJECT MANAGEMENT TECHNIQUES FOR EFFECTIVE SEWERAGE TREATMENT PLANT CONSTRUCTION

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ABSTRACT

The construction of Sewage Treatment Plants (STPs) is critical for urban environmental sustainability and public health. However, STP projects usually face difficult problems, such as time delays, cost overruns, and inefficiencies caused by insufficient project management strategies. With a focus on how to improve scheduling, resource allocation, and cost efficiency, this study examines the application of efficient construction management techniques—such as construction management, risk management, and time management—in STP projects. Using tools like as Microsoft Project (MSP) and statistical risk analysis using SPSS, this study investigates optimal practices for improving STP construction efficiency, mitigating risks, and avoiding budget overages. The study uses a case study of a STP project in Gorakhpur to give insights into site selection strategies, workflow management, and the impact of current project management tools in improving project outcomes. The findings of primary data analysis and statistical interpretation are addressed in order to provide suggestions to project managers aimed at increasing project success rates and sustainability in STP construction.

Keywords: Sewage Treatment Plant, Project Management, Construction Management, Risk Management, Microsoft Project, SPSS, Time Management, Cost Overrun, Site Selection, Case Study Analysis, Environmental Sustainability.

I. INTRODUCTION

1.1 General

In the study of wastewater management, Sewage Treatment Plants (STPs) play a pivotal role in safeguarding the environment by treating and purifying wastewater before it is discharged into natural water bodies. As municipalities and industries grapple with the escalating challenges of urbanization and industrialization, the efficient operation of STPs becomes indispensable. Amidst the multifaceted aspects of STP management, one critical facet that demands meticulous attention is cash flow management.

Cash flow management for Sewage Treatment Plants involves the strategic orchestration of financial resources to ensure the uninterrupted and optimal functioning of these vital facilities. As STPs navigate a dynamic landscape of operational costs, capital investments, and regulatory compliance, effective cash flow management becomes a linchpin for sustainability and resilience. This entails judicious allocation of funds for routine maintenance, technological upgrades, and compliance measures, while concurrently addressing the financial exigencies that may arise unpredictably.

This introduction delves into the imperative of cash flow management for Sewage Treatment Plants, exploring the unique financial challenges inherent in their operation and the strategic approaches required to navigate these challenges successfully. From operational expenditures to capital investments, regulatory adherence to environmental sustainability, the financial landscape of STPs demands a nuanced understanding and a proactive financial strategy to ensure the seamless execution of their mission to protect and preserve our water resources.

1.2 Sewer Management System

There is a need for a sewage collecting system to divert wastewater to the required destination, which is a sewage plant, for treatment to prevent direct discharge of wastewater into the environment to avoid environmental degradation.

1.2.1 Sewer Collection System

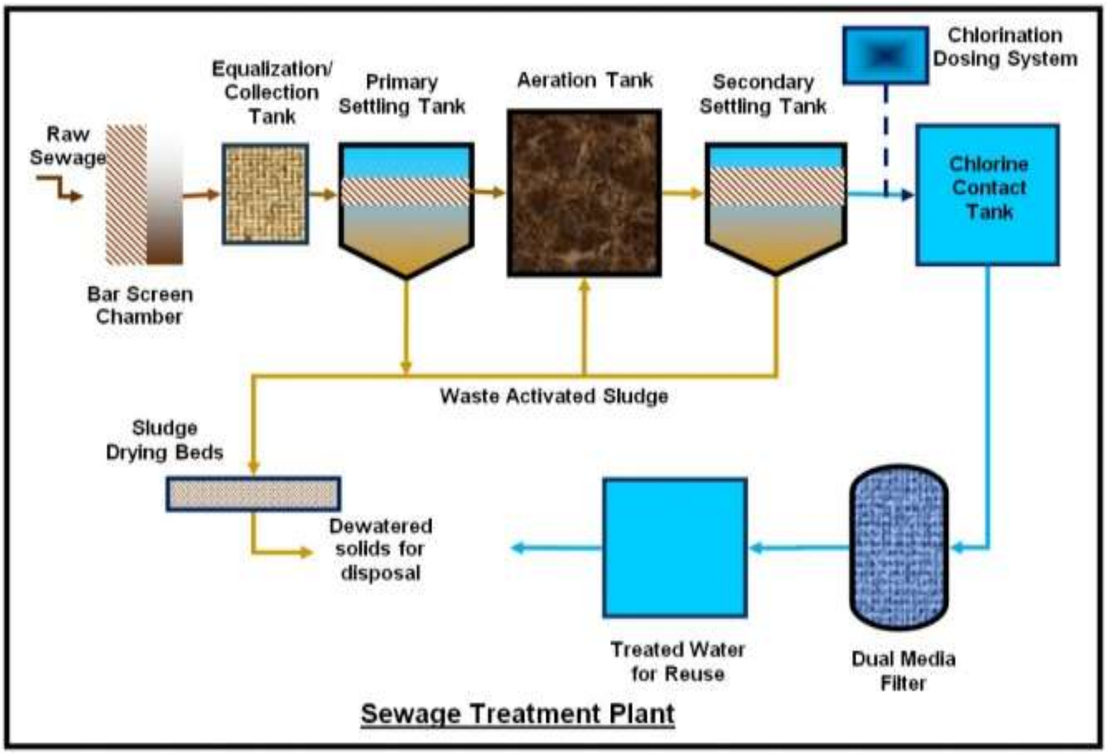
Wastewater collection systems are in responsible of collecting and transporting liquid waste to a treatment facility. The collection system, like a water distribution system, resembles a tree that branches out from the treatment facility to collect wastewater from individuals. Individual residences' wastewater enters the collecting system via a service line. The larger the population, the more intricate the structure. and the type of system used. Regardless, some storm water enters sanitary sewers through gaps, especially in older lines, as well as roof and basement drains. Sanitary sewer systems employ smaller pipes and minimize the cost of collecting wastewater because sanitary sewer lines carry far less wastewater than combined sewer lines.

1.2.2 Pumping Station

In sewage treatment plant, pumping stations are utilized to distribute, divert, stop or stabilize the water flow. The normal pumping station comprises of a tank, pumps (settled speed drives or variable speed drives), level instruments, switches, and flow instruments.

1.2.3 Sewage Treatment Plant (STP)

A sewage treatment plant is outlined to remove contaminants from sewage to deliver an effluent that's suitable for release to the surrounding environment or an aiming reuse application, in this manner anticipating water contamination from crude sewage discharges. One of the most typical things that comes in our mind with regard to human waste; is to dump it to the sewers and let the government take care of it.



1.3 Statement of the Problem

The construction of Sewage Treatment Plants (STPs) is a critical but complex undertaking that often faces significant challenges, including site selection difficulties, time delays, cost overruns, and construction inefficiencies. Despite the importance of STPs in promoting environmental sustainability and public health, many projects suffer from inadequate planning, poor project management, and insufficient risk mitigation strategies, leading to project failures or suboptimal outcomes. The lack of a structured approach to project management in STP construction exacerbates these issues, resulting in inefficiencies, delays, and budget excesses. This study seeks to address these challenges by investigating the application of effective project management techniques such as construction management, time management, and risk management in the planning and execution of STP projects. It will also examine how modern project management tools like Microsoft Project (MSP) can enhance decision-making, optimize resource allocation, and improve overall project efficiency, with a focus on minimizing delays and cost overruns. Through a case study and primary data analysis, the study will provide insights into best practices and strategies that can improve the success rate of STP projects.

1.4 Scope of the Study

The scope of this study revolves around identifying and analyzing key project management techniques that enhance efficiency in the planning and construction of STPs. This includes an in-depth review of: Preliminary site surveys and site selection strategies to ensure the optimal location for STP construction. Techniques to manage construction schedules, resources, and workflows effectively, ensuring timely completion of each project phase. Risk management strategies, including the identification, assessment, and mitigation of potential risks that could delay the project or lead to cost overruns. Modern project management tools like MSP for scheduling and resource allocation, and data analytics tools like SPSS for performance evaluation and decision-making. A case study of an STP project to perform primary data analysis using questionnaires and real-world project data, followed by statistical analysis through SPSS.

This study seeks to examine construction problems connected to project management strategies that improve efficiency in sewage treatment plant (STP) construction projects. It also focuses on evaluating preliminary survey and site selection strategies throughout the planning and construction stages to ensure successful project execution. The research also aims to ensure the effective execution of a high-quality, compliance, and sustainable STP within budget and time restrictions. Furthermore, it assesses the effectiveness of risk management and mitigation strategies in reducing delays and cost overruns during STP construction. Finally, the study looks at the function of current project management tools in boosting decision-making and overall project performance.

II. LITERATURE REVIEW

This section serves as an introduction of various technical paper published authors for institutional research and the general knowledge of wastewater treatment systems with their construction challenges, method and factor so as to choose appropriate technologies to find possible solutions.

M. Affan Badar (2020) studied economically evaluated centralized and decentralized Sewage Treatment Plants (STPs) in Sharjah, UAE. Using Net Present Value (NPV), it found that a decentralized approach (Option 3) was 44% and 23% more cost-effective than centralized options (Option 1 and Option 2), aiding infrastructure planning in metropolitan areas.

The failures and rehabilitation of conventional sewer systems as a result of poor design stresses and construction issues were covered by C. N. Damvergis (2014). The sewer systems must be properly maintained and run in order to accomplish the intended goals. It discusses "no dig technology," which refers to trenchless replacement and construction techniques such as pipe bursting, horizontal directional drilling (HDD), micro-tunneling, and pipe jacking, among others. A preventive aggressive maintenance program is required to upkeep sewer systems not only to achieve the goal of environmental protection but also for effective operations of sewer line. Priyanka T. and Ruksana T. (2019) stated that the design of a sustainable sewage treatment system is required to meet the requirements of water reclamation, recycling, and reuse in order to meet the water demands of future populations Priyanka T. and Ruksana T. (2019) stated that the design of a sustainable sewage treatment system is required to meet the requirements of water reclamation. According to them, the most difficult aspects of the process are the analysis & determination of appropriate methods of treatment & technological resources by considering a number of factors.

The sewage system plays an important role in the water resources cycle. To maintain proper hydraulic management and prevent environmental contamination of the sewer network, the various causes and types of their malfunction should be detected. Gabriella Balacco et al. (2020) investigated the causes of intervention in Southern Italian sewer networks, discovering that the most common cause of intervention is pipe blockage with exfiltration, followed by manhole occlusions. The most common causes of intervention are not factors related to the age or material of the pipe, but rather the installation method or social habits involving incorrect sewage system use. A sewage treatment plant was required for excess sewage generated by a developing municipality in Andhra Pradesh. In said case M. Bhargavi et al. (2018) undertook research to build a sewage processing facility for Vizianagaram, considering the city's expected populations over the next 30 years, as well as a number of regulations and guidelines for the quality of the water processed it can provide; with plans to reuse treated sewage water for irrigation, fire protection, and public-commercial toilet flushing, as well as treated sludge to nourish soil fertility. Prerit and Sammed (2018) investigated a zonal sewer network plan and appropriate treatment technology for a 43 MLD sewage treatment plant in light of growing global awareness and concern about water conservation and the need for new approaches to achieve sustainable water resource development. They concluded that SBR technology is more efficient in terms of safety and economy than other sewage treatment technologies used in India, with the treated sewage parameters remaining within specified parameters.

In a review, Sitesh Kumar et al. (2017) discussed the issues with the sewerage system and potential fixes. According to the 2011 census, the majority of households lack a functional drainage system. Sewerage systems are essential for improving cleanliness in a nation, and they must be accompanied by public awareness campaigns that encourage the reuse of treated sewage water and educate citizens about sewage collection, treatment, and disposal. Johan and Marius (2012) discussed the difficulties that smaller municipalities face in operating and maintaining their service infrastructure in a sustainable and cost-effective manner, which ultimately leads to service failure. This study identifies and investigates issues such as fund grant utilisation, human resource issues, and operational deficiencies. Short-term options include obtaining assistance from the private sector and securing funding for O&M in the annual budget; long-term options include repair and maintenance programmes (RAMP) and outsourcing to train corporation staff for proper skill transfer. Using the infrastructure condition assessment approach, Mohammadreza et al. (2019) evaluated the deterioration of sewer pipe systems brought on by various influences that can be avoided by maintaining sewer pipe networks. In order to minimize repeated inspections of the sewer network, sewer condition prediction models assist in providing a platform for forecasting pipe condition and choosing inspection frequency. Studies conducted between 2001 and 2019 on prediction models for sewer pipes by comparing logistic regression models, Markov chain, and According to research using linear regression models, degradation models may significantly enhance maintenance planning by forecasting the future state of sewage pipes. It also implies that the study of artificial intelligence models is required to assess the future condition and behaviour of sewer pipes.

Maaz Khan et al. (2017) investigate the need for sewage treatment plants with the goal of producing treated sewage and treated sludge for reuse. Along with the characteristics of domestic waste water, the sewage treatment process, various treatment stages involved, and design criteria are all discussed. Wetlands constructed with environmentally friendly processes such as anaerobic ponds consume less energy and have lower operating and maintenance costs. With the help of advanced technology, treated sewage water can be used for drinking. Construction of the waste water treatment facility is done in stages until it is finished. Every stage includes different requirements for functioning, such as planning, scheduling, monitoring activities, rescheduling, and finally operating or handing over. In 2019, Rejo and Gokul discussed about anticipated effects during the construction phases. The Primavera project planner software plays a significant role in treatment plant construction scheduling, and Earned Value Analysis provides the scope to identify problems during the project so that necessary measures can be taken to rectify the issues. Asset management encompasses the aspect of efficient planning for managing a sewer network over its lifetime. Dr. Ibrahim Mohammed et al. (2016) studied the state of Baghdad's sewage systems having an eye towards formulating a degradation models or functionality evaluation tools. Discriminant testing as well as statistical approaches were used in the investigation of sewage age, preparing, effectiveness, & maintenance. and Artificial Neural Network (ANN). The results of both modelling techniques provided useful information for future planning.

In general, sewage treatment plants are divided into three stages: primary, secondary, and tertiary treatment. Sucheta Sahu and Deepika Palai (2018) proposed an appropriate technology for the treatment of domestic waste water in their study. Moving Bed Bio-reactor (MBBR) technology was chosen with ultra-filtration for tertiary treatment, which is similar to reverse osmosis, due to less retention time in the process reactor and higher quality output. Treated water can be used for irrigation, landscaping, coolant, domestic/public toilet flushing, and ground water recharge or agricultural work with additional treatment and minimal chemical dosing.

III. METHODOLOGY

3.1 Research Methodology

- **Primary Data Collection (Questionnaire):**

A structured questionnaire will be designed to gather insights from project managers, engineers, and other key stakeholders involved in the STP project. The questionnaire will focus on their experiences with project management tools, risk management, and time management techniques.

- **Data Analysis:**

Data from the questionnaires and project records will be statistically analyzed using SPSS software to identify trends, patterns, and correlations between project management techniques and successful project outcomes. This will include descriptive statistics, regression analysis, and hypothesis testing to assess the impact of different management strategies on project efficiency.

- **Project Management Tools (MSP):**

Microsoft Project (MSP) will be utilized to model the project's scheduling, resource management, and progress tracking. The MSP program will help visualize the timeline, identify critical paths, allocate resources efficiently, and monitor project milestones.

By using an quantitative analysis through SPSS and MSP, this study will offer a holistic understanding of how effective project management can improve STP construction outcomes, reduce risks, and enhance decision-making processes.

3.2 Research Design

A research design is a comprehensive blueprint that guides a research project toward its goals. The researcher employed a descriptive design in this investigation. The purpose of this research was to Evaluation of a Sewage Treatment Plant in Mumbai.

3.3 Data Collection Techniques

To get the data required to meet the goals, two methods of data collection—primary & secondary—will be utilized. The techniques of investigation are shown in Figure 6.

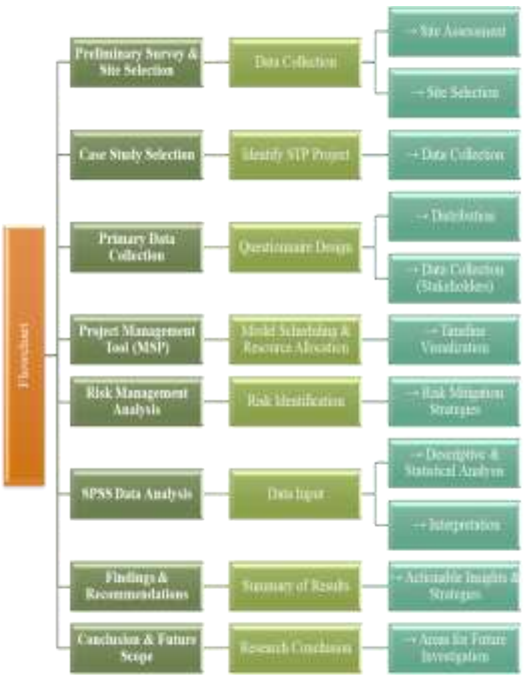


Figure 3.1: Flowchart of the study

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3.3.1 Hypothesis Formulation

H1: There are lack of technologies that are used in the taramandal sewage treatment plant.

H2: The efficiency of sewage treatment plant increases after necessary changes are done.

3.3.2 Data Collection & Sources of information

Primary and secondary data will be gathered for data collection of research.

Primary data were gathered from respondents from who will take part in the survey that will be conducted in order to check the sewage treatment, deposition etc. in the taramndal locality.

A range of published articles, research initiatives, bulletins, governmental publications, & statistics from the taramndal sewage treatment facility would be the sources of secondary data.

IV. CASE STUDY

4.1 Problem in Statement

The Gorakhpur city has an underground sewer lines of total length 55 km. out of which 6 km in trunk line. The city coverage of sewer network is only 11.66 percent. Out of total 125000 properties in the city, only 14575 properties are connected to the sewer system and 87425 properties disposed their sanitary waste on site. There is no sewerage treatment plant (STP) and other waste water treatment arrangement in the city and all the waste water is directly discharged in the nallas. The purpose of this research is to determine the sewage waste generated by the city with respect to the city's population. We will be doing this study with the data collected from the sewage treatment plant in taramndal locality only.

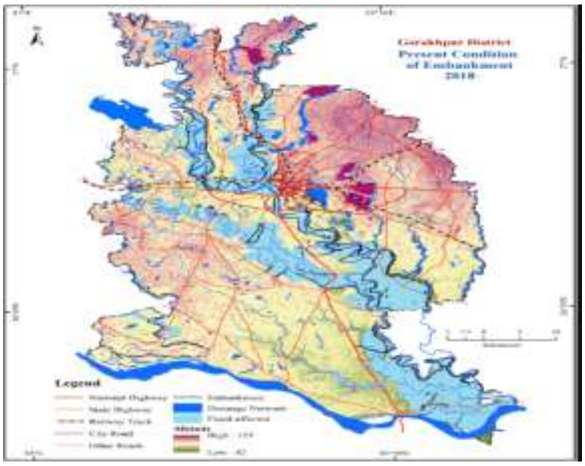


Figure 4.1: Geological map of Gorakhpur city

Today, treating wastewater is generally a complex, multi-step industrial process. The first step in a sewage treatment plant is generally some kind of mechanical treatment, where large objects and heavy materials are removed. The mechanical treatment may consist of a screening chamber (coarse and fine screening) and a degrader. To remove soluble organic matter and possibly also nitrogen from the wastewater, biological treatment is often the second step and followed by disinfection unit (Chlorine contact tank).

Figure 4.2: Google Earth Image of the Treatment Plant

Wastewater treatment plants are constructed to protect the environment from excessive overloading from different kinds of pollutants. These plants must meet the appropriate effluent standards. Abnormal process conditions at sewage treatment plants result in the release of effluent that may contain toxins and unacceptably high levels of dangerous organic and inorganic materials into various water bodies and the general environment. This study is based on Evaluation of the sewage treatment plant in Taramandal Gorakhpur because they are among the most widely-used systems in the district.

- **Background:**

Taramandal Gorakhpur Sewage Treatment Plant (STP) is a facility that treats wastewater to remove pollutants and contaminants before releasing the treated water back into the environment. The plant is located in the Taramandal area of Gorakhpur, a city in the Indian state of Uttar Pradesh.The STP in Taramandal Gorakhpur was built to treat the city's sewage and reduce the pollution of the local waterways. The plant utilizes various treatment processes such as physical, chemical, and biological methods to remove organic and inorganic contaminants from the wastewater. The Taramandal Gorakhpur STP was commissioned in 2012 under the Ganga Action Plan Phase-II, a government initiative aimed at reducing pollution in the Ganga River and its tributaries. The plant was built at a cost of approximately 68 crore rupees and covers an area of 10 acres. The plant utilizes various treatment processes such as primary treatment, secondary treatment, and tertiary treatment to remove pollutants from the wastewater. The primary treatment involves physical processes such as screening, grit removal, and sedimentation to remove large solids and particles from the wastewater. The secondary treatment involves biological processes such as aeration and sedimentation to remove dissolved organic matter from the wastewater. The tertiary treatment involves advanced processes such as filtration and disinfection to remove remaining pollutants and contaminants from the wastewater. The treated water from the Taramandal Gorakhpur STP is discharged into the Rapti River, a tributary of the Ganga River. However, due to various operational and maintenance issues, the plant has been facing challenges in meeting its treatment capacity, resulting in the discharge of untreated or partially treated wastewater into the local water bodies. This has led to the pollution of the Rapti River and its adverse impact on the environment and public health.

The plant has a design capacity of treating 30 million litres of sewage per day (MLD). However, due to various operational and maintenance issues, the plant has been facing challenges in meeting its treatment capacity, resulting in the discharge of untreated or partially treated wastewater into the local water bodies. The evaluation of the Taramandal Gorakhpur STP would involve a detailed assessment of the plant's performance in terms of its design, operation, and maintenance. The evaluation would also assess the quality of the treated water and the effectiveness of the plant's treatment processes in removing pollutants and contaminants from the wastewater.

The evaluation would involve several stages, including data collection, laboratory analysis, and site visits. The collected data would be analyzed to determine the plant's performance in meeting its treatment capacity and the quality of the treated water. The laboratory analysis would involve testing for various parameters such as biological oxygen demand (BOD), chemical oxygen demand (COD), total suspended solids (TSS), and fecal coliforms. The evaluation would also assess the plant's operational and maintenance practices to identify any deficiencies and recommend improvements. Additionally, the evaluation would assess the environmental impact of the plant's discharge on the local waterways and the effectiveness of the plant's monitoring and reporting practices.

To address the issues faced by the Taramandal Gorakhpur STP, the government has undertaken several initiatives such as upgrading the plant's infrastructure, improving the plant's operational and maintenance practices, and implementing advanced treatment processes. The government has also emphasized the need for strict monitoring and reporting practices to ensure that the plant is operating efficiently and effectively in treating the city's sewage and reducing pollution of the local waterways.

4.4 STP Working Drawings:

Table-1 outlines the standard concrete cover requirements for various structural elements within a sewage treatment plant. Each element is meticulously detailed to ensure structural integrity and longevity in harsh environmental conditions. From the foundation to columns, walls, beams, and slabs, specific concrete cover thicknesses are prescribed, ranging from 25mm to 80mm, depending on the element's location and exposure to water or other elements. Additionally, the table includes abbreviations for different concrete types, reinforcement specifications, and construction terminology, providing a comprehensive guide for construction professionals.

TABLE - 1

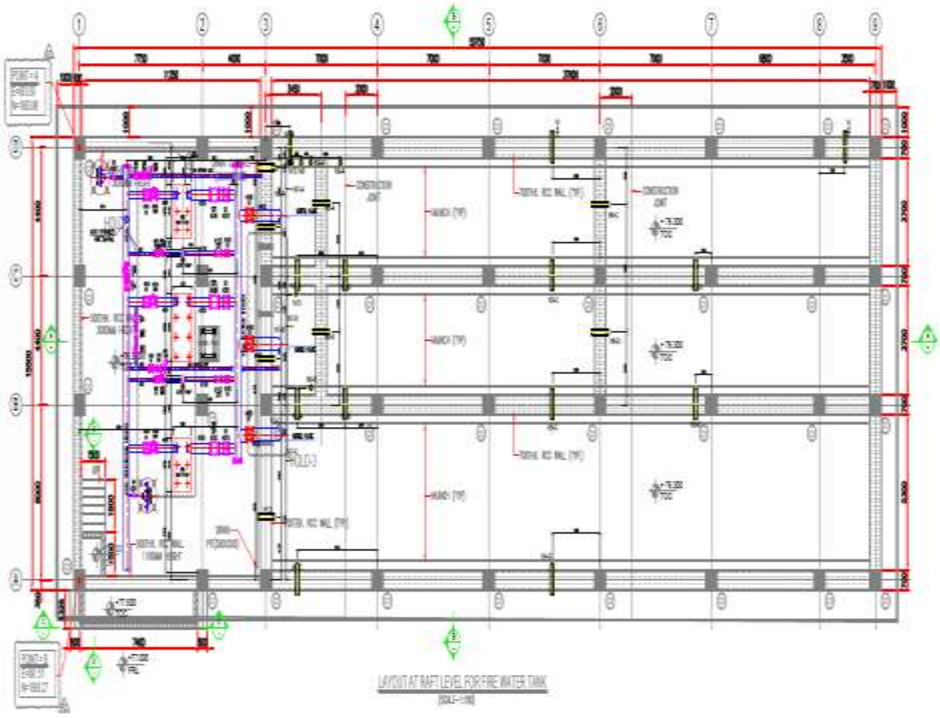
SR. NO.	STRUCTURAL ELEMENT	CONCRETE COVER
A	FOUNDATION	50mm ALL FACE
B	PILE	50mm ALL FACE
C	PILE CAP	75mm ALL FACE
D	SLAB ON GRADE	50mm TOP & BOTTOM
E	GROUND BEAM/PLINTH BEAM	40mm ALL FACE
F	COLUMN BELOW FGL	80mm ALL FACE
G	COLUMN ABOVE FGL	40mm ALL FACE
H	R.C. WALL	40mm
I	BEAM	40mm ALL FACE
J	SLAB	25mm ALL FACE
ALL R.C	MEMBER SUBMERGED IN WATER = 50 MM.	

TABLE - 2

SR. NO.	TYPE OF FORMWORK	MINIMUM PERIOD BEFORE STRIKING FORMWORK
A	VERTICAL FORMWORK TO COLUMNS, BEAMS.	24 HRS
B	SOFFIT FORMWORK TO SLABS (PROPS TO BE REFIXED IMMEDIATELY AFTER REMOVAL OF FORMWORK)	3 DAYS
C	SOFFIT FORMWORK TO BEAM (PROPS TO BE REFIXED IMMEDIATELY AFTER REMOVAL OF FORMWORK)	7 DAYS
D	PROPS TO SLABS: 1) SPANNING UP TO 4.5 M 2) SPANNING OVER 4.5 M	7 DAYS 14 DAYS
E	PROPS TO BEAMS AND ARCHES: 1) SPANNING UP TO 6 M 2) SPANNING OVER 6 M	14 DAYS 21 DAYS

Fig 4.3: Standard Drawing of Sewage Treatment Plant

In Table-2, the focus shifts to formwork requirements, crucial for shaping concrete during construction. It specifies the types of formwork needed for columns, beams, and slabs, including minimum periods before removing the formwork to ensure proper curing and structural strength. Different durations are stipulated based on the type of formwork and the span of the structural members, with longer periods required for larger spans to support the concrete adequately until it gains sufficient strength. This meticulous attention to detail in both Table-1 and Table-2 reflects the rigorous standards essential for the successful construction of sewage treatment plants, where durability and resilience are paramount.



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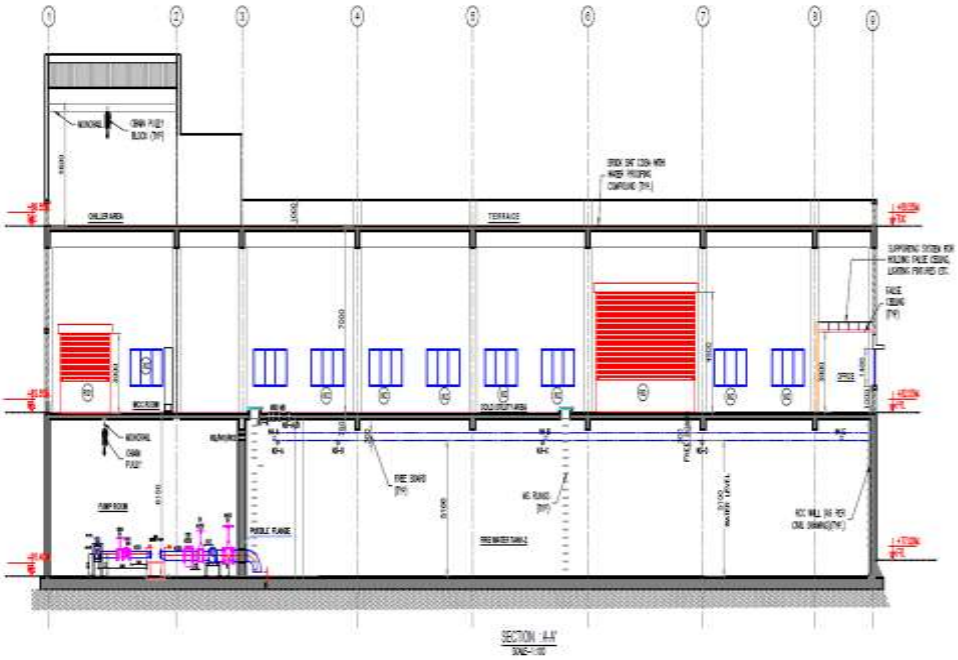

Fig 4.5: PLOT PLAN of Sewage Treatment Plant

The plot plan for the sewage treatment plant (STP) nozzle configuration delineates a structured layout essential for the efficient operation and management of the facility. At an elevation of FFL+82.55 meters, the nozzles are strategically positioned to fulfill various functions crucial to the plant's functionality. Starting with N1 A/B/C, a 400 NB nozzle, designated for the discharge of fire water from the tank outlet, located at COP (-)77.16 meters, establishes a vital safety measure. Following is N2, a 200 NB nozzle serving as the fire test line, positioned at COP (+)81.61 meters, ensuring regulatory compliance and readiness.

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