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EXPERIMENTAL ANALYSIS OF SEQUENCING BATCH REACTOR DESIGN AND OPERATIONAL CONSIDERATION OF SWERAGE TREATMENT PLANT

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Abstract - *As per the appointment as Consultants for the preparation of Detailed Project Report for the Sewerage project of Sehore city we are presenting this document. The project has been prepared for the future population of 2047 which is estimated as 1,73,100.It is presumed that at the time of commissioning of project, water supply shall be available @ 135 lpcd and accordingly the rate of sewage flow has been taken as (80% of water supply) 108 lpcd. Ground water infiltration @250 liters per manhole has been considered. As far as possible the design has been carried out for gravity flow in the sewer. For sewer lines having velocity of flow less than the minimum velocity (self cleansing velocity 0.6 m/s) suitable remedial measures shall be adopted at the time of operation and maintenance. Looking to the ground topography the entire town has been bifurcated in Three Zones and accordingly separate STP have been provided on Sequencing Batch Reactors (SBR) technology for achieving the effluent parameter as per MOEF guidelines to be disposed on land or water sources. Under the proposed project laterals / Manholes for house connection have also been provided. As far as possible the project has been prepared considering the existing scenario of sewerage system which is mainly through open drains. The data regarding possible sites of STPs, Rate of water supply & flow of sewage has been collected from Municipal Council, Sehore. Any discrepancy may kindly be brought to our knowledge immediately. The designs in this project report has been prepared as per relevant clauses of CPHEEO Manual on Sewerage and Sewage treatment. The design of sewer network has been done on SEWER - CAD. This is a draft report for the approval of Municipal Council, Sehore and the State Government. The contents should not be used for construction purpose or the items of estimate should not be used as items to call the tenders without the prior approval of the competent authority.*

Key Words **AMURT1, BOD2, COD3 LPCD4, MLD5, SBR6, DWF7, HDPE8**

1. INTRODUCTION

Sehore is located on latitude 22*05' North and longitude 76*40' East. The general level is about 502 meters above M.S.L. (1500.00 ft. to 2000.00 ft.) Sehore is located 39 Kilometres away from state capital Bhopal towards south and on Bhopal – Indore Highway. It is also connected by rail From Bhopal to Ratlam. The total Municipal area is approximately 16.01 Sq kms. The population as per 2011 census is 109118. The average rainfall of the District is 942.10 mm. Maximum average temperatures in summer is 31.5^{0}C & minimum average temperature in winter is 19.1^{0}C. Sehore is well connected with major urban nodes like Icchawar, Shyampur, and Ashta. Town is also well connected with surrounding villages like Bijora, Avantipura, Gopalpura, Shahpur kodia, Mungispura, Alahda Khedi, Vadia Khedi, Chanderi, Tokopur, Thoorna Khurd, and Semli Khurd etc within the district. Sehore town is situated on the banks of River Seewan and is developed over an almost flat landform. River Seewan is a perennial river and it divides the town into two halves. Lotiya Nallah also flows through the centre of the Town before merging into River Seewan. The natural slope of the toen is in the North Western direction. The City Falls in the Chambal River Basin and the Seewan River collects the entire storm water to Parbhati River which ultimately goes on to meet Chambal. In addition to the various offices of the sehore District administration, several educational institutions are located here. A Government Degree Collage, Collage of Agriculture, an Engineering collage and various other schools are located here. Sehore mainly has Agro based Industries in the town. This is mainly due to the abundant availability of raw materials required for the functionality of these types of industries. Agro Based industries mainly include Sugar Mill, Paper Mill, Oil Mill and industries based on vegetable produce. There are other industries related to manufacturing of Bronze and Brass Utensils, furniture, Ara Mill and Bone Factory. The industries are mainly located on Narsingh Road. Brick Kilns and Earthen Ware manufacturing industries currently located on the bank of Seewan River near Badiakhedi Botanical Garden.The business and economy of Sehore is mainly based on Agriculture. There are several old Irrigation tanks in the area. Seewan River also flows nearby. Wheat, Jowar, Dhal etc. are the main crops of the area along with Sugarcane. A sugar factory has been set up because of good sugarcane crop. Agro based industries are there.

1.2 Need for this project:

The total installed capacity of Sehore water supply system at present is 23.50 MLD. The water is being supplied mainly

from Parvati River, Jamunia Tank and Bhagwanpura Tank which shall enable to fulfill the water @ 135 lpcd shall be supplied to the town. The main components of the scheme are as below,

Table – 1 : Location Information of Project

Source	Parvati River, Jamunia and Bhagwanpura Tank
Intake	15 m Height and 6 m diameter each
Raw Water Pumps	3 Nos. Vertical turbine pumps each
Raw Water Rising main	300-350 mm CI/DI pipe 10500 m long
Treatment plant	8.10 MLD, 8.00 and 6.75 MLD
Service reservoir	10 no. Total cumulative capacity of 5.70 ML
Distribution system	GI/CI/PVC/AC 15000 m

1.3 Salient Features of Designs:

Sewer network for the Sehore town is designed on Bentley Sewer Cad Software. The diameters of the sewer line are being calculated as per the designs from software. Minimum diameter is being taken as 150 mm. The diameter adopted for design & estimate is as below,

Table – 2: Silent features of Design

S. No.	Design Diameter	Outer Diameter	Remark
1	150	160	HDPE - DWC
2	170	200	HDPE - DWC
3	250	295	HDPE - DWC
4	400	480	HDPE - DWC
5	450	450	RCC – NP4
6	500	500	RCC – NP4
7	600	600	RCC – NP4
8	700	700	RCC – NP4
9	800	800	RCC – NP4

1.4 Design Parameters

The sewer network has been designed for gravity flow. However, where gravity flow is not possible pumping has been proposed. The design has been carried out with the help of Bentley Sewer-CAD. The input parameters are as follows

Table – 3: Design Parameters

S. No.	Particulars	Minimum	Maximum
1	Dia. of Pipe (mm)	150	700
2	Velocity(m/s)	0.60	3.00
3	Slope(m/m)	1/2000	1/100
4	Cover	0.60	3.00

The design has been carried out to achieve minimum velocity of 0.60 m/s for the ultimate design flow. However looking to small town and less population density the velocity in initial lengths are very less. It is therefore suggested to have flushing in these pipes, by sewer flushing machine at a desired frequency. Also the slope of the sewer lines has been restricted to the extent possible so as to restrict the trench depth for reducing excavation cost and for ease in operation in maintenance after the commissioning of the project.

1.5 Objective of the study

- An average flow of 80% of water supply @ 135 lpcd i.e. 108 lpcd has been adopted.
- The hydraulic design load varies from component to component of the treatment plant. Henceforth, all appurtenances, conduits, channels etc. has been designed for the maximum flow i.e. 2.25 times the average flow.
- Sedimentation tanks have been designed on the basis of average flow, while consideration of both maximum and minimum flow has been given importance for designing of screens and grit chambers.
- The velocity shall range within 0.6 mps to 2.1 mps.
- Sewers shall be at no point of time run more than 80% full. Based on this values of v/V, q/Q and d/D has been adopted as illustrated for Manning's Formula in Manual.

2. LITREATURE REVIEW

Much research has been carried out to understand the beneficial effects of using fibbers as reinforcement in soil. Introduction of natural fibber makes the soil a composite material with improved strength and stiffness as compared to unreinforced soil.

[1]. **Gray, D.H., and Ohashi, H.,(1983),** concluded from their experiments that the peak shear strength of soil

increases on reinforcement with natural, synthetic and metallic fibbers .

[2].**Ranjan, G., Vasan, R.M. and Charan, H.D., (1996),** carried out axial compression test on cohesionless soils reinforced with discrete ,randomly distributed fibres, both synthetic and natural and showed that increase in strength is a function of fibber weight fraction, aspect ratio and soil grain size.

[3]. **Singh and Bagra (2013),** showed that CBR value of soil increases on introducing jute fibre . The effect of coir fibre waste on Kaolinite clay sub-grade has been studied and it showed significant amount of improvement in the dry density and CBR values ofkaolinite clay on addition of 2% fibbers.

[4]. **R.R Singh and Er. Shelly Mittal** showed that CBR and UCS values of clayey soil-coir fiber mix increases with increasing percentage of fibbers. Among all the natural fibers jute can withstand rotting and heat; also it has the highest tensile strength. Natural fibers need tobe coated with phenol or bitumen so as to improve its durability

[5]. **Sivakumar Babu and Vasudevan 2008** This study is focuses on influence of jute and coir fiber on the CBR value of locally available soil. With the help previous results on normal unreinforced soil and soil reinforced with varying amounts of jute and coir fiber.

The CBR values of reinforced soil have been compared with that of unreinforced soil and the thickness of the flexible pavement using reinforced soil and unreinforced soil as sub grade also compared.

3. METHODOLOGY

The design of process flow sheet involves selection of an appropriate combination of various unit operations and unit processes to achieve a desired degree of contaminant removal. The selection of unit operations and processes primarily depends on the characteristics of raw waste water and the required levels of contaminants permitted in the processed effluents. The design of process flow sheets is very important step in the overall design of waste water treatment and requires a thorough understanding of the treatment units and associated unit operations/ processes along with the mechanisms involved and performance levels attainable under variable conditions. It calls for optimization of waste water treatment system coupled with stage wise optimal design of individual operation/ process to achieve a minimal cost design. The main contaminants in domestic waste water to be removed are biodegradable organics, as usually measured by BOD, suspended solids and pathogens with the first two having been traditionally considered as the performance indicators for various treatment units. The objective of domestic waste water treatment plant will be to produce treated effluents having BOD5 of 30 mg/l or less and suspended solids of 50 mg/l or less so as to disposal it into inland water bodies. The conventional process flow sheet of municipal wastewater treatment plant comprises the unit operations of screening, grit removal and primary sedimentation followed by unit process of aerobic biological treatment usually achieved by activated sludge process or trickling filter followed by secondary sedimentation. The sledges removed by primary and secondary sedimentation are digested an aerobically followed by drying of an aerobically digested sludge on sand sludge drying beds. The activated sludge process or trickling filter process are replaced by low cost treatment devices such as oxidation pond, aerated lagoon or waste stabilization ponds. Such treatment devices obviate the necessity of some of the unit operations and processes like primary sedimentation and anaerobic digestion. Also they are low in capital as well as O&M cost. With the better understanding of microbiology and biochemistry of anaerobic treatment, it is now feasible to treat dilute organic wastewater such as domestic wastewater also directly through anaerobic treatment using recently developed innovative devices such as Up flow Anaerobic Sludge Blanket Reactor (UASBR), Fluid-Bed Submerged Media Anaerobic Reactor (FB-SMAR) and Anaerobic Filter (AF) or Static-Bed SMAR(SB-SMAR) and Anaerobic Rotating Biological Contractor (AnRBC). Though enough field data is to be generated as yet on their performance. It is generally reported that BOD5 removal efficiencies may range from 60-80%. Consequently cost treatment will generally be required to achieve the prescribed effluent standards.

3.1 Selections of suitable processes

Sewage treatment processes may be generally classified as primary, secondary and tertiary. The general yardstick of evaluating the performance of sewage treatment plants is the degree of reduction of BOD, SS and Total Coliforms. The efficiency of a treatment plant depends not only on proper design and construction but also on good operation and maintenance. Expected efficiencies of various treatment units are given Table

Table – 4 : Efficiencies of Various Treatment Units

S. No.	Process	SS	BOD	Total Coliform
1	Primary Treatment (Sedimentation)	45-60	30-43	40-60
2	Chemical Treatment	60-80	45-65	60-90
3	Secondary Treatment	-	-	-

(i)	Standard trickling filters	75-85	70-90	80-90
(ii)	High Rate trickling filters	-	-	-
	A. Single stage	75-85	75-80	80-90
	B. Two Stages	90-95	90-95	90-60
(iii)	Activated sludge plants	85-90	85-95	90-96
(iv)	A. Stabilization ponds(Single Cell)	80-90	90-95	90-95
	B. Stabilization ponds(Two Cell)	90-95	95-97	95-98

Tertiary treatment is adopted when reuse of effluent for industrial purposes is contemplated or when circumstances dictate the requirement of higher quality effluents. Cost is the prime consideration in the selection of the treatment method. It should include the cost of installation, capitalized cost of maintenance and operation taking into account interest charges and period of amortization. An alternative considering the annual cost covering amortization and interest charges for the loan obtained for the installation together with the annual operating and maintenance costs. In our case there is a component of subsidy granted by the Government for the installation of the treatment works and the maintenance cost is to be borne entirely by the local body. Other factors that are influencing are ease of construction and maintenance, benefits that accrues from better environmental sanitation, location, availability of land and topographical conditions. We have designed Trickling Filter as well as Waste stabilization ponds. However looking to all the above parameters we feel that waste stabilization pond is better in terms of low O&M cost as no power is required, but Trickling filter is better in terms of less requirement of Land. Thus it is suggested to go for Stabilization pond.

4. RESULTS

Design of Sewage Treatment Plant (STP-1) for Sehore Town Gopalpura Industrial area

Table 5: Design of Sewage Treatment Plant (STP-1) for Sehore Town Gopalpura Industrial area

Design Population	18226
Sewage flow @ 108 lpcd	1968 Cum /day
(80% of water supply @ 135lpcd)	-
Total design flow	1968 Cum/day
Taking BOD of raw water 150 mg/l	-
Because of dilution of raw water with	-
Ground water.	-
Raw BOD5	200 mg/l
Final BOD5	30 mg/l
Average ambient air temperature in winter	19.1^0 C
Average ambient air temperature in summer	31.5^0 C
Lagoon size	-
Assume detention time	5 days
Lagoon volume	1968 x 5 =9840 Cum
Let Lagoon dimensions be	145 x 17 x 4 m3 9860 Cum

Lagoon winter temperature
(Detention Time/hr)= (Ti-Tl)/F (TL-Ta)
Ti= Temperature of influent waste water
Ta= Temperature of ambient air
TL= Temperature in Lagoon
h = Depth of lagoon
f = Heat transfer coefficient

$5/4 = (25 - T_L)/0.49(T_L - 19.1)$

2.45 TL – 46.80 = 100 -4TL

6.45 TL = 146.80
TL = 22.76^0C

Estimation of K
Assume K at 20^0C = 0.7 per day
Hence, K at 22.72^0C = 0.7 x $(1.035)^{2.76}$
= 0.770 /day

D/UL Estimations

Keeping lagoon geometry such that flow conditions are plug-flow type (i.e. D/UL = 0.2 approx.). This will possible if a long and narrow lagoon (17 m x 145 m) is provided or baffles are

provided within the rectangular lagoon of 34 m x 73 m to give a winding flow with the same effect.

BOD5 Removal Efficiency (in winter)
K x detention time = 0.770 x 5
= 3.85

Table 6 : Calculation Table

December, 1993 for K x detention time= 3.85 & D/UL = 0.2		
Soluble BOD removal efficiency = 92.5 %		
Namely soluble BOD in effluent = 15 mg/l		
Suspended solids likely to flow out in effluent		=42 mg/l (say)
BOD of VSS = 0.77 (0.6 x 42)	=	19.40 mg/l (20 say)
Hence BOD of effluent =15 + 20	=	35 mg/l
Overall efficiency in winter	=	(200-35)/200
	=	0.825 i.e, 82.5%

In other months of the year, the efficiency will be higher and effluent BOD will be less than the above value. Adopting 82.5% for further calculations

Table 7: Power Requirement For Project

Power Requirement	
When efficiency	82.5 % and all BOD is removed Aerobically
Power requirement/year	13 x 18226 236938 kw/year
Power requirement/hour	236938/365/24 =27.048 kw/h

Taking power requirement 13 kWh/person/year & oxygenation capacity of aerators is 2.0 Kg Oxygen/kWh as per manual.

Table 8: Area Calculation

O2 requirement/day	0.825 x 13 x 18226 /365 x 2 Kg/day 267.77 kg/day 11.15 kg/hr
Power needed	11.15 / (0.825) (2 Kg O2/KWh) 6.76 kw
Power level in Lagoon	6.76 kw x 1000 / 9860 0.686W/cum (acceptable)
Land Requirement Net lagoon area	2465 sqm (17 m x 145 m)
slopes	3698 Sqm
Area/person	3698 / 18226 0.202 sqm/person

However looking to the land requirement we have proposed extended aeration (SBR) for the sewage treatment. The area required for SBR shall be 1/5th of the area designed above (740 Sq.m) and the same is in possession of Municipal Council Sehore furthermore the effluent characteristics of SBR is as per MPPCB norms for water to be discharged in inland water ways.

5. CONSLUSION '

1. Arithmetic Progression method has given the population projection on the lower side. This method is not suitable for the city like Sehore. Being situated on Indore-Bhopal corridor and proximity the town have fair prospects to grow in near future. The probable population worked out in this method growth of 43% in 36 years (2011-2047) which is almost 1.19% per annum or 12% for decade. The projection of the future population given in these methods is less than the average growth rate of Madhya Pradesh. Hence the population projection seems to be on lower side.

2. The probable population worked out in the Geometric Progression method shows a growth of 154% in 36 years (2011-2047) which almost 4.2 percentage per annum or 42% per decade. Hence looking to the future development aspects of Sehore the population projection given by this method seems to be very much on higher side.

3. Incremental Increase method improves the figures obtained by Arithmetic method and shows a growth of 59% in 36 years, which almost 1.64% per annum or 16% per decade. The projection of the future population given is in line with the average growth rate of Madhya Pradesh. Henceforth, gives a projection which is realistic and can be adopted for design purpose

4. In case of Graphical Method the population projection figures are close to Geometric progression method and seem to be far from realistic Figures. The method shows a growth of 177% in 36 years (2011-2047) which is almost 4.91% per annum or 49% per decade. This projection is far more than the average growth rate of Madhya Pradesh. Hence the population projection figures obtained in this method and are on higher side and can't be acceptable for design purposes.

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