# ANALYSIS AND DESIGN OF 10 MLD SEWAGE TREATMENT PLANT BY USING STADD.PRO


**SYED ZAKEER[1], MOHD ZAKEER[2]**

[1] *PG Student, M.Tech in Structural engineering, Department of Civil Engineering, Nawab Shah Alam Khan College of Engineering and Technology,*(affiliated to JNTUH)new Malakpet, Talib Khundmiri road, Hyderabad, Telangana state, India 2018.

[2] *Assistant Professor, M.tech in Structural engineering, Department of Civil Engineering, Nawab Shah Alam Khan College of Engineering and Technology, ,*(affiliated to JNTUH)new Malakpet, Talib Khundmiri road, Hyderabad, Telangana state, India 2018.



***ABSTRACT: Design and Analysis of 10 MLD Sewage Treatment Plant using of staad pro in limit state method analysis of staad pro methods used in STAAD-Pro analysis are Limit State Design conforming to Indian Standard Code of Practice. STAAD.Pro features a state-of-the-art user interface, visualization tools, powerful analysis and design engines with advanced finite element and dynamic analysis capabilities. From model generation, analysis and design to visualization and result verification, STAAD.Pro is the professional's choice. [2-D/3-D] initially for all possible load combinations [dead, live, wind and seismic loads].STAAD.Pro has a very interactive user interface which allows the users to draw the Structures and input the load values and dimensions. Then according to the specified criteria assigned it analyses the structure and designs the members with reinforcement details for RCC frames .The Water Retaining structures are designed as per IS 3370, the structures which are not in contact with water are designed as per the IS 546. Complicated and Sewage Treatment Plant structures Comprising various components such as Wet well, SBR, Blower Room, Centrifuge Room, Chlorine Tonner Room, Sludge Thickener, Admin Building need very time taking and cumbersome calculations using conventional manual methods. STAAD.Pro provides us a fast, efficient, easy to use and accurate platform for analysing and designing structures.***



***Key words: 10 MLD Sewage Treatment, limit state method, STAAD-Pro analysis, RCC frames, the IS 546.***


## I.INTRODUCTION

### Existing Sewerage System

The Sewerage Network is well connected to almost all buildings in the project area. There are 2219 quarters, Public buildings, Guest houses, post office, NGT hostel beach emirs, German quarters, GM

office, CISF camp office etc., at Centenary Colony. In these 2219 quarters, there are 1930 ST2 type quarters, 154 C2 type quarters, Rani Rudrama Devi

stadium, 23 NA & NB (Official buildings for Officers), 112 NC type quarters, Public buildings, Guest houses, post office, NGT hostel beach emirs, German quarters, GM office and CISF camp in

Centenary Colony.The Sewage is collected into locally distributed septic tanks. There are 9 septic tanks in the project area.

### Project Conceptualization

Proper sanitation and good hygienic conditions are essential for human survival, health and dignity. Contaminated water bodies and discharging waste water in the midst of residential localities can cause severe health problems.The principal objective of wastewater treatment is generally to allow human and industrial effluents to be disposed of without danger to human health or unacceptable damage to the natural environment.

Waste water is thus to be treated in order to:

-  remove organic and inorganic matter which would otherwise cause pollution
-  remove pathogenic (disease causing) organisms
-  protect the Environment and Human Health

**NEED OF THE PROJECT**

The need is twofold. One is the environmental aspect and the other is the utility aspect.

In line with Swachh Bharat Mission, with a drive to reduce pollution, the sewage disposal system is to be upgraded for meeting the standards. As the existing facilities are obsolete and dysfunctional, there is an urgent need for adopting a suitable method to tackle the wastewater in an ecofriendly manner.

As Mr. Ismail Serageldin, Vice President, World Bank-1995 rightly pointed out "Many of the wars this century were about oil, but those of the next century will be over water". Recycle and reuse is the need of the day for preserving our precious natural resources. Treated wastewater can cater to horticulture needs in public parks and areas of gardening. It can even be used for flushing of toilets, cleaning of floors, tools, plants and machinery by laying specific lines.

**OBJECTIVE OF THE STUDY**

The main objective of the study is to develop a technically viable plan by adoption of appropriate Technology and Construction of Sewage Treatment Plant at Centenary Colony.

It is envisaged that, upon completion of the study, the opportunity to take advantage of benefits will result in:

Rapid implementation to deliver the project on a fast track schedule.

Significant improvements in protection of human health.

Enhancement of the overall ecological environment.
Improvement in quality of life by ensuring availability of organized and flexible schemes and plans for implementing short-term and long-term sewerage infrastructure improvements suitable for future development.

Opportunities for improvements in institutional and organizational capacity for sustainable solutions, with possible full cost recovery and coordination among various institutions for cost-effective capital improvements and operation and maintenance activities.

**GENERAL SCOPE OF THE STUDY**

As per the Terms of Reference, the scope of the study can be summarized as follows:

Preparation of Detailed project report by conducting Survey, feasibility studies for collecting the sewage at optimal location, assessing the flow and its quality in the project area, finalize the STP capacity, recommend suitable method by comparative study of alternative technologies and provide design criteria and technical details for tendering process to construct STP on EPC/Turnkey basis.

## II. LITERATURE REVIEWS

**Thalapathy .M et al.,** had done "ANALYSIS AND ECONOMICAL DESIGN OF WATER TANKS". In this paper he said this project gives the detailed analysis of the design of liquid retaining structure using working stress method. This paper gives idea for safe design with minimum cost of the tank and give the designer relationship curve between design variable. This paper helps in understanding the design philosophy for the safe and economical design of water tank.

**B.V. Ramana Murthy, M Chiranjeevi** had done the "DESIGN OF RECTANGULAR WATER TANK BY USING STAAD PRO SOFTWARE". IN this paper he said that this mini project is conducted for a period of 15 days from 21-05-2010 to 07-06-2010 to have complete practical knowledge of various techniques and problems faced in the field. A different topic like Construction Aspects, Design Parameters, Details of Formwork, Details of reinforcement, Process of Water Treatment Plant and Execution have been dealt with in the course of our mini project.

## III.METHODOLOGY, CONCEPTS AND DESIGN CRITERIA

**Study of Existing system**

The Sewerage Network is well connected to almost all buildings in the project area and Septic tanks. The entire project area is divided into 5 Clusters based on sewage disposal (Refer Drawing No. EMSOL/DR/ESCI/SCCL-RGIII/0101).Cluster 1 consists of 1930 nos of ST2 type quarters which are for Employees and labourers and it is the biggest area in the colony. The sewage flows of these quarters are connected to 3 septic tanks located at north of Sivaramnagar near oxidation ponds.Cluster 2 consists of 154 nos of C2 type quarters and Rani Rudrama Devi stadium which are for Employees. The sewage flows of these quarters are connected to the septic tank in this cluster that is located at the back side of the C2 type quarters.Cluster 3 consists of 4 nos of A type quarters and 19nos of NB (official building) type quarters which are for higher grade officers. There is one Septic tank in this cluster that is located at the back side of the NB type quarters. The sewage flows of these quarters are connected to the septic tank.Cluster 4 consists of 112 nos of NC type quarters, Ramagiri guest house, Hostel, OC II project office, Chummeries, Transit Accommodation for employees, Visitors etc. There are 2 septic tanks in this cluster, located at backside of NC type quarters. The sewage flows of these quarters are connected to 2 septic tanks.Cluster 5 consists of GM office, CISF camp office. The Septic tank in this cluster is located near the CISF camp. The sewage flows of these quarters are connected to the septic tank.The sewerage lines at places are choked and at some places are broken, causing obstructions to the flow. Desiccated manholes and gushing flows substantiate obliterated network.

**Detailed survey**

A Detailed Survey is done to check the feasibility of interconnecting Septic tanks and to recommend appropriate alignments. Invert levels are taken for all the inlets at respective septic tank locations. Ground levels at the proposed STP site are taken.

The consultant has considered the characteristics of the raw sewage as follows:

- BOD : 220 mg/L
- COD : 300 mg/L
- TSS : 400 mg/L
- TKN : 40 mg/L
- Phosphorous : 25mg/L
- Faecal Coliform : >106 Col/100ml

**Analysis of Outlets and Sewerage Route**

The collector sewer route is chosen taking cognizance of the following:

- Ground slope
- The existing sanitation infrastructure
- Other existing developments
- Future expansion plan
- Location of treatment works

**Design Consideration**

The consultant developed methodology, concepts and criteria for undertaking the detailed design of the proposed assignment in reference to policy documents, legislations, codes and standards identified.The system to improve the environment of the Colony consists of subsystem, major part of which is sewage, its collection, treatment and disposal or reuse. This DPR has proposed design of conveyance system for sewage from present outlets, dealt in depth with the treatment and disposal.Domestic sewage consists of mainly liquid waste from toilets, kitchen, baths and washing of floors. The liquid waste is also generated from industries, commercial establishment etc. The liquid waste of township, having no industries, is purely of domestic nature. It is generallyconveyed to a suitable place out of the limits of the proposed master plan area through sewers/rising main and then treated to such an extent that the effluent meets the standards laid down by the State Pollution Control Board for final disposal on the land or natural water courses.

**Treatment**

**Analysis of Treatment Processes**

The important criterion of a wastewater treatment system design is its suitability to the local conditions. There are many aspects that must be considered when designing wastewater treatment facilities to ensure that the design will not only meet the treatment standards, but that it will also be able to work within the local technical and economic environ. The wastewater treatment design hinges around the influent and effluent criteria.

The dependability of performance of a process lies in spite of fluctuations in influent quality and quantity. The process must ensure a stable effluent quality. Similarly, ability to withstand power and operational failure is a consideration in the final choice of process. The more sophisticated the process the more sensitive is its operation. Some processes like digesters, lagoons, and ponds are sensitive to temperature. Wastewater treatment processes that typically will be considered are described below:

**Secondary Treatment System Option**

The secondary treatment system is in use in most sewage treatment facilities. There are several secondary treatment options that could be used in local conditions. Each option has a unique set of advantages and disadvantages that must be considered in relation to each individual site. Various factors affecting selection of secondary treatment processes include:

i. Land
ii. Power supply availability and dependability
iii. Operating (and control) equipment and its indigenous availability
iv. Skilled staff
v. Nature of maintenance problems
vi. Extent of sludge production and disposal requirements
vii. Loss of head through plant in relation to available head (to avoid/ minimize pumping as far as possible)
viii. Ease of strategic expansion of plant capacity over time

**Standards for Treatment**

Revised Indian Standards for discharge of sewage in surface waters are given in the table below

| *Characteristic of the Effluent* | *Tolerance limit for Discharge of Sewage in surface water* |
|---|---|
| BOD5 | 10 mg/L |
| TSS | 10 mg/L |

The unit operations and processes commonly employed in domestic wastewater treatment, their functions and units used to achieve these functions are given in the following table

Unit Operations/Processes, Their Functions and Units Used

| Unit Operations/Processes | Functions | Treatment Devices |
|---|---|---|
| Screening | Removal of large floating, suspended and settleable solids | Bar racks and screens of various Description |
| Grit Removal | Removal of inorganic suspended solids | Grit chamber |
| Primary Sedimentation | Removal of organic/inorganic settleable solids | Primary sedimentation tank |
| Aerobic Biological Suspended Growth Process | Conversion of colloidal, dissolved and residual suspended organic matter into settleable biofloc and stable inorganics | Activated sludge process units and its modifications, Waste stabilization ponds, Aerated lagoons |
| Aerobic Biological Attached Growth Process | same as above | Trickling filter, Rotating biological Contactor |
| Anaerobic biological growth processes | Conversion of organic matter into $CH_4$ & $CO_2$ and relatively stable organic residue | Anaerobic filter, Fluid bed submerged media anaerobic reactor, Upflow anaerobic sludge blanket reactor, Anaerobic rotating biological contactor |
| Anaerobic Stabilization of Organic Sludge | same as above | Anaerobic digester |

**Technology Selection**

Treatment technologies can be classified into four broad groups:

- Natural system
- Conventional Technologies
- Advanced Technologies
- Emerging Technologies

**Advanced Technologies**

The consultant had submitted the preliminary report to Singareni Collieries Companies Limited (SCCL) and advised to consider any of the above technologies. Based on various factors, SBR and

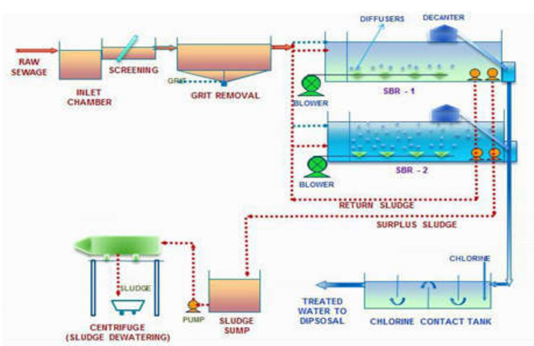
MBBR technology options were shortlisted.In order to understand functioning of these technologies in a better way, the concerned SCCL officials have visited some of the plants with SBR and MBBR technologies. And finally, the SCCL has opted for SBR technology for their proposed Sewage Treatment Plant at Centenary Colony, RG-III.

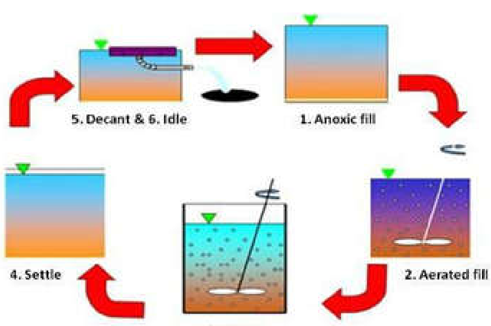
**Sequencing Batch Reactor (SBR)**

**TECHNOLOGY**

This variant of ASP technology is essentially a batch treatment by combining primary settling, aeration, secondary settling and decanting the treated sewage in a series of sequenced and/or simultaneous reactions in the same basin on a time deferred cycle. As different from the well-known reaction kinetics of continuous flow steady state ASP for our sewage characteristics, the bio-kinetic reaction rate in this non-steady state batch process needs to be evaluated for its higher rate or otherwise.

Schematic diagram of Sequencing Batch Reactor process




**Treated Sewage Quality**

The treated sewage quality of final effluent for which sewage treatment plant is designed and to be guaranteed by the contractor during operation and maintenance period is as under:

BOD 5 days at 200C :

Suspended Solids :

Total Nitrogen as N :

Dissolved Phosphorous as P :

Faecal Coliform Count after chlorination :

**Process Description**

The treatment works will receive flows from the sewer system and will undergo preliminary treatment consisting of inlet screens, grit removal and if required Fat oil and grease (FOG) removal.Flows will be forwarded to a biological treatment stage where, in conjunction with aeration, bacteriawill treat the sewage and be separated from the treated effluent before discharge.The Treatment works shall be based on a continuous inflow sequencing batch reactor (SBR) process. The SBR process shall be based on distinct phases for nitrification, de-nitrification, phosphorus release and uptake, which are controllable by duration of air-on and air-off/mixing phases to provide operational flexibility.In each continuous inflow SBR basin, the activated sludge is alternately aerated and mixed over a number of pre-determined cycles. Solids liquid separation shall occur during a settling phase of the cycle. After the settling phase, treated effluent shall be decanted or withdrawn from the liquid surface. Flow to the vessel is not interrupted at any time.The functions of flow equalization, biological oxidation, nitrification, denitrification, phosphorus release and uptake, sedimentation and aerobic sludge stabilization shall all be carried out in a single basin. Systems that require reactor bypassing during the settle and/or decant phases shall not be acceptable.

**Design Requirements**

**SBR Hydraulic Design**

All structures pipes and processes shall be capable of handling maximum flows with one tank or unit in each treatment process stream isolated for maintenance. The complete secondary treatment stream shall not incur a head loss greater than 2.4 m.

Every weir shall have a scum guard to ensure that no floating material passes at all times while the weir is operating.

Hydraulic peaks will be managed by reducing the treatment cycle times, and thus increasing the number of decants per day.

The system should be designed in such a way that process is hydraulically capable of passing 100% of the design and peak flow with one basin out of operation. The decanter mechanisms and sizing should be designed to cope up with this feature. The sludge settlement times shall be shown to be sufficient to have a 0.9 m clear water zone between the sludge blanket and the end of the decant zone at this period to stop sludge blanket carryover.

**SBR Aeration Design Requirements**

Actual Oxygen Requirement (AOR) calculations shall be based on the design BOD and Nitrogen loads. A de-nitrification benefit for oxygen recovery is acceptable. An alpha factor (α) of 0.65 and Beta factor (β) of 0.95 shall be used in the Standard Oxygen Transfer Requirement (SOTR) calculations, provided as part of the document submittal requirements.The aeration system shall be designed to be able to provide sufficient aeration at both average and maximum aeration depth, and shall be shown in the aeration calculations.All air flows rates will be specified at Normal (20 0C, 1 bar and 0% humidity) air volumes. The aeration calculations shall include for local air intake maximum temperatures, humidity and elevation as follows:

| | |
|---|---|
| Maximum Ambient Temperature | 45 0C |
| Relative Humidity | 55 % |
| Site Elevation | 162 m |

Aeration shall be full floor coverage fine bubble aeration. Aeration design and blower capacity shall allow for peak loads from diurnal variations.The aeration design shall include the piping and pressure loss at maximum aeration requirement. The blower shall be specified to achieve the maximum air flow and pressure.The aeration system shall control the dissolved oxygen to an operator adjustable set point. Air flow rate shall be controlled by direct signal to the blower to increase or reduce air output, and not by an air control valve. The aeration piping shall have a control valve for control isolation of each aeration-main per tank.

**SBR Control Requirements**

The design control philosophy and detailed functional statement shall be proved by the process designer. The system designer shall provide the control system for the secondary biological treatment system.Variable speed aeration control shall be provided to give dissolved oxygen control of the system.The control philosophy shall allow for increasing or decreasing the nitrification and de-nitrification capacity of the system.Any electromagnetic decanter shall be controlled to drive down through the water so that the weir starts at the design top water level (TWL) at the start of the decant period and reaches bottom water level (BWL) at the end of the decant period.

**DESIGN REPORT FOR CHLORINE CONTACT TANK FOR PROPOSED 10-MLD-STP DESIGN PHILOSOPHY**

**Project Title:** Design of CHLORINE CONTACT TANK for the Proposed 10 MLD STP

**Scope of the Project:** Structural Analysis & Design of CHLORINE CONTACT TANK as per IS codes.

The Water Retaining structures are designed as per IS 3370, the structures which are not in contact with water are designed as per the IS 546.

**Design Data:**

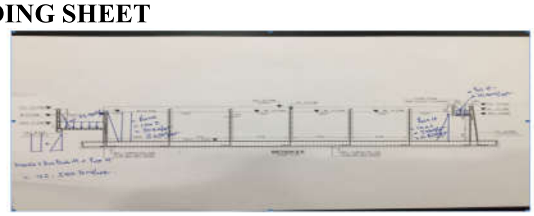
1. Grade of Concrete: M30 (Liquid Retaining Structures)
2. Density of Concrete: 25 kN/m³
3. Grade of Steel: Fe 500
4. Safe Bearing Capacity: 70 kN/m² (Refer soil Report)

**Minimum Cover to Main Reinforcement:**

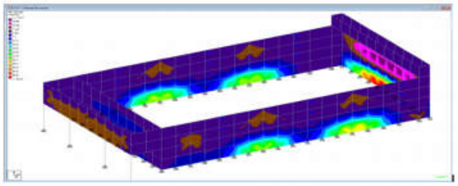
1. Base Slab: 40 mm
2. Beams: 25 mm
3. Columns: 40 mm
4. Footings: 50 mm
5. All Walls: 40 mm

All the structural elements are analyzed as per the IS codes of practice for a given set of loads and Load combinations (Refer References).

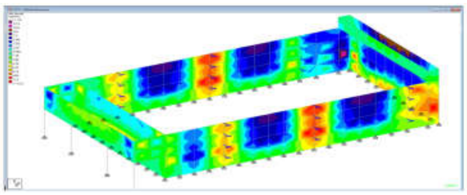
**LOADING SHEET**



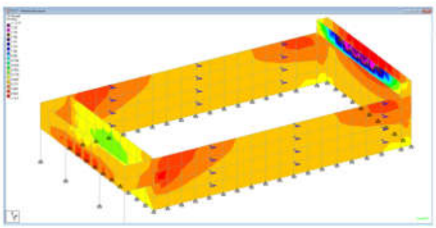
**STRESSES FROM CCT**



**MY- Vertical Moment-HYDROSTATIC LOAD**



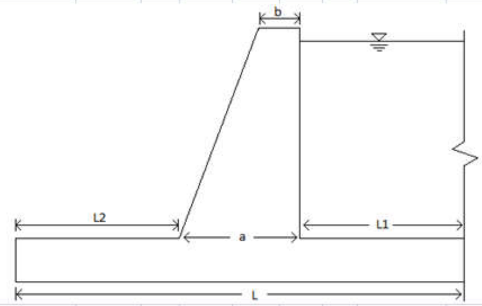
**Horizontal Moment-HYDROSTATIC LOAD *MX-***



**SX-Axial Tension-HYDROSTATIC LOAD**

**DESIGN OF CCT MAIN WALL FOOTING MAIN WALL**

**LOADCASE-1 HYDROSTATIC PRESSURE**






**TERMINOLOGY**

| | | | |
|---|---|---|---|
| Unit Weight Of Soil = | γs | 18 | kN/m3 |
| Unit Weight Of Soil Under Fully Saturation | γsat | 21 | kN/m3 |
| Unit Weight Of Concrete= | γc | 25 | kN/m3 |
| Unit Weight of Water = | γw | 10 | kN/m3 |
| coefficient of friction= | μ= | 0.5 | |
| Earth pressure coefficient= | Ka= | 0.33 | |
| Angle of internal friction= | Φ= | 30 | 0.5235 rad |

**WALL DIMENSIONS**

| | | |
|---|---|---|
| Wall thk. at base,a | = | 0.35 |
| Wall thk at top,b | = | 0.2 |
| Total Height of Wall Tapering (m) | = | 3.5 |
| Height of Water inside the tank,h | = | 3.5 |
| Length of footing (Inside) (L1) | = | 2 |
| Length of footing (Outside) (L2) | = | 1 |
| Depth of | = | 0.6 |
| Soil outside | = | 0 |
| Height of Wall from top to | = | 3 |

**DESIGN DATA**

| | | |
|---|---|---|
| Grade of concrete $f_{ck}$ = | 30 | N/mm² |
| Grade of steel $f_y$ = | 500 | N/mm² |
| Safe NET bearing pressure = | 87.5 | KN/m² |
| Thickness of footing (D) = | 600 | mm |
| Clear cover of footing = | 50 | mm |
| Main bar dia of footing = | 12 | mm |
| Effective depth of footing, d = | **544** | mm |
| Overturning moment (From Staad), Mo = | 55 | kN-m |
| factor of safety = | 1.4 | |
| Line of action of resultant of vertical forces with | | |

**SUPPORT REACTIONS FOR SERVICE LOAD COMBINATIONS - ISOLATED FOOTINGS**

| NODE | L/C | Fx kN | Fy kN | Fz kN | Mx kNm | Mz kNm | Qmax | | SBC<87.5 | L | B | ID |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Horizontal | Vertical | Horizontal | Moment | Moment | | | | | | |
| 515 | 5 DL+HL | 3.279 | 206.851 | -1.498 | -1.58 | -4.724 | 56.45 | 46.99 | OK | 2 | 2 | F1 |
| 515 | 7 DL+HL+HL-LAUNDER | 3.279 | 206.857 | -1.497 | -1.58 | -4.724 | 56.45 | 46.99 | OK | 2 | 2 | F1 |
| 516 | 5 DL+HL | 3.279 | 206.835 | 1.497 | 1.578 | -4.725 | 56.44 | 46.99 | OK | 2 | 2 | F1 |
| 516 | 7 DL+HL+HL-LAUNDER | 3.28 | 206.841 | 1.496 | 1.578 | -4.725 | 56.44 | 46.99 | OK | 2 | 2 | F1 |
| 515 | 2 HL | 3.253 | 118.112 | -1.206 | -1.292 | -4.538 | 33.91 | 25.16 | OK | 2 | 2 | F1 |
| 516 | 2 HL | 3.254 | 118.097 | 1.205 | 1.29 | -4.539 | 33.9 | 25.16 | OK | 2 | 2 | F1 |
| 515 | 1 DL | 0.026 | 88.738 | -0.291 | -0.288 | -0.185 | 22.54 | 21.83 | OK | 2 | 2 | F1 |
| 516 | 1 DL | 0.026 | 88.737 | 0.291 | 0.288 | -0.185 | 22.54 | 21.83 | OK | 2 | 2 | F1 |
| 513 | 5 DL+HL | 1.434 | 45.264 | -2.708 | -2.806 | -1.761 | 14.75 | 7.9 | OK | 2 | 2 | F1 |
| 513 | 7 DL+HL+HL-LAUNDER | 1.435 | 45.284 | -2.708 | -2.806 | -1.762 | 14.75 | 7.9 | OK | 2 | 2 | F1 |
| 514 | 7 DL+HL+HL-LAUNDER | 1.436 | 45.236 | 2.706 | 2.805 | -1.763 | 14.74 | 7.89 | OK | 2 | 2 | F1 |
| 514 | 5 DL+HL | 1.435 | 45.216 | 2.706 | 2.805 | -1.762 | 14.73 | 7.88 | OK | 2 | 2 | F1 |
| 513 | 1 DL | -0.099 | 45.691 | -0.644 | -0.616 | 0.069 | 11.94 | 10.91 | OK | 2 | 2 | F1 |
| 514 | 1 DL | -0.099 | 45.688 | 0.644 | 0.616 | 0.069 | 11.94 | 10.91 | OK | 2 | 2 | F1 |
| 513 | 2 HL | 1.553 | -0.427 | -2.063 | -2.19 | -1.829 | 2.91 | -3.13 | OK | 2 | 2 | F1 |
| 514 | 2 HL | 1.554 | -0.473 | 2.062 | 2.188 | -1.831 | 2.9 | -3.14 | OK | 2 | 2 | F1 |
| 513 | 4 HL-LAUNDER | 0.001 | 0.02 | 0 | 0 | -0.001 | 0.01 | 0.01 | OK | 2 | 2 | F1 |
| 514 | 4 HL-LAUNDER | 0.001 | 0.02 | 0 | 0 | -0.001 | 0.01 | 0.01 | OK | 2 | 2 | F1 |
| 515 | 4 HL-LAUNDER | 0.001 | 0.006 | 0 | 0 | -0.001 | 0.01 | 0.01 | OK | 2 | 2 | F1 |
| 516 | 4 HL-LAUNDER | 0.001 | 0.006 | 0 | 0 | -0.001 | 0.01 | 0.01 | OK | 2 | 2 | F1 |

## Design of Roof Slab

| | | | | | |
|---|---|---|---|---|---|
| Fy = | 500 N/mm² | | Ly = | 6.200 m | |
| Fck = | 25 N/mm² | | Lx = | 6.125 m | |
| Clearcover | 20 mm | | | | |
| Slab thickr | 150 mm | | eam width | 300 mm | |
| D.L.of slab | 3.750 | | Ley = | 6.025 m | |
| Floor finisl | 1.500 | | Lex = | 5.95 m | |
| Partition | 0.000 | | | | |
| Live load = | 1.500 | | dx= | 125 | |
| Total | 6.750 | | dy= | 115 | |
| | kN/m² | | | | |
| Ly/Lx = | 1.013 | | | Ast Required | A |

| | | | | | |
|---|---|---|---|---|---|
| Edge Cond | One long edge continuous | | | Ast | 10 mm |
| Mx- = αx*1.5*w* | 0.058 | 20.82 kN-m | | 410 | 192 c/c |
| Mx+ = αx*1.5*w* | 0.044 | 15.61 kN-m | | 302 | 260 c/c |
| | | | | | 10 mm |
| My- = αy*1.5*w* | 0.000 | 0.00 kN-m | | 180 | 436 c/c |
| My+ = αy*1.5*w* | 0.044 | 15.59 kN-m | | 331 | 237 c/c |

Check for deflection

| | | | |
|---|---|---|---|
| fs = | 167 | | |
| Pt = | 0.42 | Modification factor = | 1.90 |
| required = | 120.7 | | |
| provided = | 125.0 **O.K** | | |

## DESIGNREPORTFORBLOWERROOMFORPROPOSED 10-MLD-STP

## DESIGN PHILOSOPHY

**Project Title:** Design of BLOWER ROOM for the Proposed 10 MLD STP

**Scope of the Project:** Structural Analysis & Design of BLOWER ROOM as per IS codes.

The Water Retaining structures are designed as per IS 3370, the structures which are not in contact with water are designed as per the IS 546.

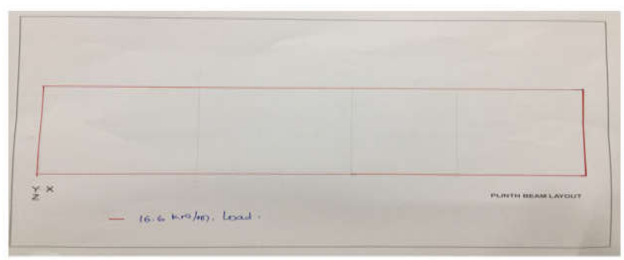
**Design Data:**

5. Grade of Concrete: M30 (Liquid Retaining Structures)
6. Density of Concrete: 25 kN/m³
7. Grade of Steel: Fe 500
8. Safe Bearing Capacity: 70 kN/m² (Refer soil Report)

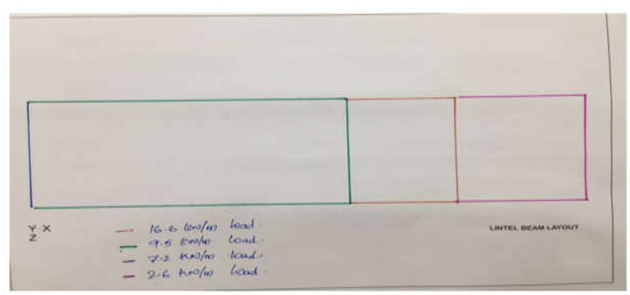
**Minimum Cover to Main Reinforcement:**

6. Base Slab: 40 mm
7. Beams: 25mm
8. Columns: 40 mm
9. Footings: 50 mm
10. All Walls: 40 mm

All the structural elements are analyzed as per the IS codes of practice for a given set of loads and Load combinations (Refer References).




16.6 kn/m - 230 MM BRICK WALL LOAD




16.6 kn/m -230 MM BRICK WALL LOAD
9.5 kn/m -230 MM BRICK WALL LOAD
7.2 kn/m -230 MM BRICK WALL LOAD
2.6 kn/m -PARAPET WALL LOAD

| BEAM NO | TOP REINFORCEMENT REQUIRED | | | BOTTOM REINFORCEMENT REQUIRED | | | TOP REINFORCEMENT REQUIRED | | |
|---|---|---|---|---|---|---|---|---|---|
| | LEFT | MIDDLE | RIGHT | LEFT | MIDDLE | RIGHT | LEFT | MIDDLE | RIGHT |
| 1000 | 1022.52 | 0 | 1022.52 | 212.67 | 346.04 | 334.75 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1001 | 830.23 | 0 | 1101.96 | 213.69 | 370.58 | 220.88 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1002 | 830.23 | 0 | 1101.96 | 213.69 | 370.58 | 220.88 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1003 | 619.06 | 0 | 619.06 | 416.88 | 213.69 | 234.95 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1004 | 956.62 | 0 | 779.56 | 0 | 302.13 | 247.58 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1005 | 956.62 | 0 | 779.56 | 0 | 302.13 | 247.58 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1006 | 750.82 | 0 | 750.82 | 556.56 | 213.69 | 308.48 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1007 | 720.74 | 0 | 646.12 | 213.69 | 213.69 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1008 | 720.74 | 0 | 646.12 | 213.69 | 213.69 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1009 | 616.98 | 0 | 616.98 | 420.7 | 213.69 | 237.65 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1010 | 772.88 | 0 | 751.35 | 214.2 | 288.49 | 364.2 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1011 | 772.88 | 0 | 751.35 | 214.2 | 288.49 | 364.2 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 1012 | 788.92 | 0 | 788.92 | 0 | 327.53 | 219.51 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2000 | 0 | 214.2 | 214.2 | 0 | 0 | 0 | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/ |
| 2001 | 214.2 | 214.2 | 0 | 0 | 0 | 0 | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/ |
| 2002 | 655.45 | 0 | 714.49 | 214.2 | 232.39 | 214.2 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2003 | 655.45 | 0 | 714.49 | 214.2 | 232.39 | 214.2 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2004 | 0 | 214.2 | 214.2 | 0 | 0 | 0 | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/ |
| 2005 | 214.2 | 214.2 | 0 | 0 | 0 | 0 | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/c | 2L 8i @ 300mm c/ |
| 2006 | 634.57 | 0 | 663.34 | 213.69 | 214.63 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2007 | 634.57 | 0 | 663.34 | 213.69 | 214.63 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2008 | 916.11 | 1168.5 | 1433.05 | 311.42 | 272.34 | 251.54 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 300mm c/ |
| 2009 | 910.26 | 0 | 910.26 | 313.05 | 574.31 | 466.7 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2010 | 1433.05 | 1168.5 | 916.11 | 229.96 | 272.34 | 292.32 | 2L 8i @ 300mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2011 | 660.03 | 0 | 714.62 | 213.69 | 311.99 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2012 | 660.03 | 0 | 714.62 | 213.69 | 311.99 | 213.69 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2013 | 1736.67 | 0 | 1736.67 | 367.94 | 1087.06 | 518.43 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2014 | 621.81 | 0 | 469.44 | 214.2 | 230.87 | 278.49 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2015 | 621.81 | 0 | 469.44 | 214.2 | 230.87 | 278.49 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2016 | 570.27 | 0 | 570.27 | 0 | 404.38 | 229.19 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 2017 | 687.76 | 0 | 687.76 | 214.2 | 214.2 | 223.23 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 3000 | 659.79 | 0 | 659.79 | 0 | 402.51 | 211.32 | 2L 8i @ 290mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 290mm c/ |
| 3001 | 470.82 | 0 | 777.48 | 0 | 416.46 | 200.94 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 3002 | 470.82 | 0 | 777.48 | 0 | 416.46 | 200.94 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 3003 | 1070.13 | 0 | 1070.13 | 201.45 | 824.93 | 449.11 | 2L 8i @ 280mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 280mm c/ |
| 3004 | 780.52 | 0 | 582.79 | 0 | 427.75 | 306.87 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 3005 | 780.52 | 0 | 582.79 | 0 | 427.75 | 306.87 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 3006 | 1057.51 | 0 | 1057.51 | 0 | 427.56 | 250.75 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 4000 | 621.83 | 0 | 621.83 | 0 | 338.27 | 201.45 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 4001 | 286.41 | 0 | 233.57 | 200.94 | 200.94 | 200.94 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 4002 | 286.41 | 0 | 233.57 | 200.94 | 200.94 | 200.94 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |
| 4003 | 723.57 | 0 | 723.57 | 200.94 | 332.49 | 227.13 | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/c | 2L 8i @ 150mm c/ |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 6 | 42 DL+EL(-X) | 21.414 | 339.775 | -18.657 | -14.715 | -42.387 | 50.65 | OK | 2 | 2 | F1 |
| 1 | 50 DL+LL-EL(-X) | 21.44 | 353.391 | 18.675 | 14.724 | -42.42 | 51.97 | OK | 2 | 2 | F1 |
| 6 | 50 DL+LL-EL(-X) | 21.44 | 353.391 | -18.675 | -14.724 | -42.42 | 51.97 | OK | 2 | 2 | F1 |
| 1 | 44 DL+EL(-Z) | 12.367 | 345.032 | 40.334 | 61.926 | -9.313 | 56.17 | OK | 2 | 2 | F1 |
| 6 | 43 DL+EL(+Z) | 12.367 | 345.032 | -40.334 | -61.926 | -9.313 | 56.17 | OK | 2 | 2 | F1 |
| 1 | 52 DL+LL+EL(-Z) | 12.393 | 358.649 | 40.351 | 61.935 | -9.346 | 55.7 | OK | 2 | 2 | F1 |
| 6 | 51 DL+LL+EL(+Z) | 12.393 | 358.649 | -40.351 | -61.935 | -9.346 | 55.7 | OK | 2 | 2 | F1 |
| 2 | 26 DL+LL | -1.166 | 443.391 | -6.072 | -4.445 | 1.126 | 66.32 | OK | 2.2 | 2.2 | F2 |
| 7 | 26 DL+LL | -1.166 | 443.391 | 6.072 | 4.445 | 1.126 | 66.32 | OK | 2.2 | 2.2 | F2 |
| 4 | 26 DL+LL | 2.105 | 458.93 | -4.955 | -3.437 | -2.357 | 65.88 | OK | 2.2 | 2.2 | F2 |
| 9 | 26 DL+LL | 2.105 | 458.93 | 4.955 | 3.437 | -2.357 | 65.88 | OK | 2.2 | 2.2 | F2 |
| 4 | 42 DL+EL(-X) | 21.421 | 391.343 | -2.853 | -1.895 | -42.457 | 66.34 | OK | 2.2 | 2.2 | F2 |
| 9 | 42 DL+EL(-X) | 21.421 | 391.343 | 2.853 | 1.895 | -42.457 | 66.34 | OK | 2.2 | 2.2 | F2 |
| 4 | 43 DL+EL(+Z) | 4.192 | 356.254 | -30.222 | -60.098 | -3.842 | 66.51 | OK | 2.2 | 2.2 | F2 |
| 9 | 44 DL+EL(-Z) | 4.192 | 356.254 | 30.222 | 60.098 | -3.842 | 46.51 | OK | 2.2 | 2.2 | F2 |
| 2 | 42 DL+EL(-X) | 24.625 | 409.377 | -4.12 | -2.974 | -35.884 | 67.28 | OK | 2.2 | 2.2 | F2 |
| 7 | 42 DL+EL(-X) | 24.625 | 409.377 | 4.12 | 2.974 | -35.884 | 67.28 | OK | 2.2 | 2.2 | F2 |
| 2 | 43 DL+EL(+Z) | -0.338 | 381.584 | -26.833 | -55.176 | -0.101 | 67.42 | OK | 2.2 | 2.2 | F2 |
| 7 | 44 DL+EL(-Z) | -0.338 | 381.584 | 26.833 | 55.176 | -0.101 | 67.42 | OK | 2.2 | 2.2 | F2 |
| 4 | 41 DL+EL(+X) | -25.251 | 413.801 | -2.855 | -1.895 | 37.776 | 67.68 | OK | 2.2 | 2.2 | F2 |
| 9 | 41 DL+EL(+X) | -25.251 | 413.801 | 2.855 | 1.895 | 37.776 | 67.68 | OK | 2.2 | 2.2 | F2 |
| 2 | 41 DL+EL(+X) | -27.086 | 417.43 | -4.057 | -2.927 | 39.267 | 68.5 | OK | 2.2 | 2.2 | F2 |
| 7 | 41 DL+EL(+X) | -27.086 | 417.43 | 4.057 | 2.927 | 39.267 | 68.5 | OK | 2.2 | 2.2 | F2 |
| 2 | 50 DL+LL-EL(-X) | 24.689 | 439.354 | -6.103 | -4.469 | -35.949 | 50.49 | OK | 2.2 | 2.2 | F2 |
| 7 | 50 DL+LL-EL(-X) | 24.689 | 439.354 | 6.103 | 4.469 | -35.949 | 50.49 | OK | 2.2 | 2.2 | F2 |
| 2 | 51 DL+LL+EL(+Z) | -0.274 | 411.821 | -28.806 | -56.67 | -0.165 | 50.63 | OK | 2.2 | 2.2 | F2 |
| 7 | 52 DL+LL+EL(-Z) | -0.274 | 411.821 | 28.806 | 56.67 | -0.165 | 50.63 | OK | 2.2 | 2.2 | F2 |
| 2 | 49 DL+LL+EL(+X) | -27.022 | 447.327 | -6.04 | -4.422 | 39.202 | 51.68 | OK | 2.2 | 2.2 | F2 |
| 7 | 49 DL+LL+EL(+X) | -27.022 | 447.327 | 6.04 | 4.422 | 39.202 | 51.68 | OK | 2.2 | 2.2 | F2 |
| 4 | 50 DL+LL-EL(-X) | 21.441 | 447.701 | -4.954 | -3.437 | -42.474 | 52.13 | OK | 2.2 | 2.2 | F2 |
| 9 | 50 DL+LL-EL(-X) | 21.441 | 447.701 | 4.954 | 3.437 | -42.474 | 52.13 | OK | 2.2 | 2.2 | F2 |
| 4 | 51 DL+LL+EL(+Z) | 4.222 | 412.712 | -32.333 | -61.64 | -3.859 | 52.3 | OK | 2.2 | 2.2 | F2 |
| 9 | 52 DL+LL+EL(-Z) | 4.222 | 412.712 | 32.333 | 61.64 | -3.859 | 52.3 | OK | 2.2 | 2.2 | F2 |
| 2 | 44 DL+EL(-Z) | -2.123 | 444.873 | 18.646 | 49.275 | 2.484 | 52.93 | OK | 2.2 | 2.2 | F2 |
| 7 | 43 DL+EL(+Z) | -2.124 | 444.873 | -18.646 | -49.275 | 2.484 | 52.93 | OK | 2.2 | 2.2 | F2 |
| 4 | 49 DL+LL+EL(+X) | -25.23 | 470.16 | -4.955 | -2.437 | 37.759 | 53.66 | OK | 2.2 | 2.2 | F2 |
| 9 | 49 DL+LL+EL(+X) | -25.23 | 470.16 | 4.955 | 2.437 | 37.759 | 53.66 | OK | 2.2 | 2.2 | F2 |
| 4 | 44 DL+EL(-Z) | 1.978 | 448.791 | 24.514 | 56.309 | -0.84 | 54.3 | OK | 2.2 | 2.2 | F2 |
| 9 | 43 DL+EL(+Z) | 1.978 | 448.791 | -24.514 | -56.309 | -0.84 | 54.3 | OK | 2.2 | 2.2 | F2 |
| 2 | 52 DL+LL+EL(-Z) | -2.059 | 474.76 | 16.663 | 47.78 | 2.419 | 55.56 | OK | 2.2 | 2.2 | F2 |
| 7 | 51 DL+LL+EL(+Z) | -2.059 | 474.76 | -16.663 | -47.78 | 2.419 | 55.56 | OK | 2.2 | 2.2 | F2 |
| 4 | 52 DL+LL+EL(-Z) | 1.996 | 505.149 | 22.414 | 54.766 | -0.855 | 59.52 | OK | 2.2 | 2.2 | F2 |
| 9 | 51 DL+LL+EL(+Z) | 1.996 | 505.149 | -22.414 | -54.766 | -0.855 | 59.52 | OK | 2.2 | 2.2 | F2 |
| 3 | 41 DL+EL(+X) | -32.374 | 458.654 | -0.262 | -0.033 | 43.562 | 61 | OK | 2.6 | 2.6 | F3 |
| 8 | 41 DL+EL(+X) | -32.374 | 458.654 | 0.262 | 0.033 | 43.562 | 61 | OK | 2.6 | 2.6 | F3 |
| 3 | 43 DL+EL(+Z) | -4.941 | 413.584 | -24.553 | -72.795 | 3.61 | 61.77 | OK | 2.6 | 2.6 | F3 |
| 8 | 44 DL+EL(-Z) | -4.941 | 413.584 | 24.553 | 72.795 | 3.61 | 61.77 | OK | 2.6 | 2.6 | F3 |
| 3 | 26 DL+LL | -6.058 | 531.58 | -1.688 | -1.096 | 5.092 | 61.82 | OK | 2.6 | 2.6 | F3 |
| 8 | 26 DL+LL | -6.058 | 531.58 | 1.688 | 1.096 | 5.092 | 61.82 | OK | 2.6 | 2.6 | F3 |
| 3 | 42 DL+EL(-X) | 20.592 | 490.376 | -0.265 | -0.035 | -33.626 | 62.17 | OK | 2.6 | 2.6 | F3 |
| 8 | 42 DL+EL(-X) | 20.592 | 490.376 | 0.265 | 0.035 | -33.626 | 62.17 | OK | 2.6 | 2.6 | F3 |
| 3 | 49 DL+LL+EL(+X) | -32.54 | 515.789 | -1.686 | -1.095 | 43.695 | 65.56 | OK | 2.6 | 2.6 | F3 |
| 8 | 49 DL+LL+EL(+X) | -32.54 | 515.789 | 1.686 | 1.095 | 43.695 | 65.56 | OK | 2.6 | 2.6 | F3 |
| 3 | 51 DL+LL+EL(+Z) | -5.109 | 470.979 | -25.979 | -72.846 | 3.734 | 66.32 | OK | 2.6 | 2.6 | F3 |
| 8 | 52 DL+LL+EL(-Z) | -5.109 | 470.979 | 25.979 | 72.846 | 3.734 | 66.32 | OK | 2.6 | 2.6 | F3 |
| 3 | 50 DL+LL-EL(-X) | 20.425 | 547.421 | -1.69 | -1.097 | -33.503 | 66.69 | OK | 2.6 | 2.6 | F3 |
| 8 | 50 DL+LL-EL(-X) | 20.425 | 547.421 | 1.69 | 1.097 | -33.503 | 66.69 | OK | 2.6 | 2.6 | F3 |
| 3 | 44 DL+EL(-Z) | -6.841 | 535.126 | 24.027 | 72.726 | 6.326 | 51.66 | OK | 2.6 | 2.6 | F3 |
| 8 | 43 DL+EL(+Z) | -6.841 | 535.126 | -24.027 | -72.726 | 6.326 | 51.66 | OK | 2.6 | 2.6 | F3 |
| 3 | 52 DL+LL+EL(-Z) | -7.007 | 592.181 | 22.602 | 71.675 | 6.45 | 55.76 | OK | 2.6 | 2.6 | F3 |
| 8 | 51 DL+LL+EL(+Z) | -7.007 | 592.181 | -22.602 | -71.675 | 6.45 | 55.76 | OK | 2.6 | 2.6 | F3 |

## Design of Roof Slab

| | | | |
|---|---|---|---|
| Fy = | 500 N/mm² | Ly = | 6.200 m |
| Fck = | 25 N/mm² | Lx = | 4.250 m |
| Clearcover | 20 mm | | |
| Slab thickness = | 150 mm | Beam width | 300 mm |
| D.L.of slab = | 3.750 | Ley = | 6.025 m |
| Floor finishes = | 1.500 | Lex = | 4.075 m |
| Partition | 0.000 | | |
| Live load = | 5.000 | dx= | 125 |
| Total | 10.250 kN/m² | dy= | 115 |

Ly/Lx = 1.479

| | | | Ast | | Ast Required | Ast Provided |
|---|---|---|---|---|---|---|
| Edge Condition= One long edge continuous | | | | | 10 mm | 10 |
| $Mx- = \alpha x*1.5*w*lx^2$ | 0.084 | 21.35 kN-m | 421 | | 186 c/c | 150 |
| $Mx+ = \alpha x*1.5*w*lx^2$ | 0.063 | 16.01 kN-m | 310 | | 253 c/c | 150 |
| | | | | | 10 mm | 10 |
| $My- = \alpha y*1.5*w*lx^2$ | 0.000 | 0.00 kN-m | 180 | | 436 c/c | 150 |
| $My+ = \alpha y*1.5*w*lx^2$ | 0.044 | 11.11 kN-m | 231 | | 339 c/c | 150 |

Check for deflection

fs = 172

Pt = 0.42 Modification factor = 1.85

d required = 84.9

d provided = 125.0 **O.K**

## CONCLUSIONS

One is the environmental aspect and the other is the utility aspect.

In line with Swachh Bharat Mission, with a drive to reduce pollution, the sewage disposal system is to be upgraded for meeting the standards. As the existing facilities are obsolete and dysfunctional, there is an urgent need for adopting a suitable method to tackle the wastewater in an ecofriendly manner.

As Mr. Ismail Serageldin, Vice President, World Bank-1995 rightly pointed out “Many of the wars this century were about oil, but those of the next century will be over water”. Recycle and reuse is the need of the day for preserving our precious natural resources. Treated wastewater can cater to horticulture needs in public parks and areas of gardening. It can even be used for flushing of toilets, cleaning of floors, tools, plants and machinery by laying specific lines.

**References**

**Codes & Standards:**

1. IS 456 – 2000 : Code of Practice for Plain & Reinforced Concrete
2. IS 875 – 1987: Codes of Practice for Design Loads ( Part 1 to IV)
3. IS 1893 -2002_Part- I: Criteria for Earthquake Resistant Design
4. SP 16- 1980 : Design Aids for Reinforced Concrete
5. SP 34 - 1987 : Hand Book For Concrete Reinforcement & Detailing

Book: Design Principles & Detailing of Concrete Structures by Prof. D.S.Prakash