International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252

The Study of Effective Location of Sewage Treatment Plant on Refuge Area Floor in High-rise Building

[1]Palak Gugale, [2]Shrikant Chavan, [3]Pakshal Palrecha, [4]Nikita Patil, [5]Akshay Magar, [6]Dr. S. S. Angalekar

[1,2,3,4,5]*UG Student, Department of Civil Engineering, SinhgadCollege of Engineering, Pune, India*
[6]*Professor, Department of Civil Engineering, SinhgadCollege of Engineering Pune, India*

Date of Submission: 14-06-2023 Date of Acceptance: 24-06-2023

ABSTRACT:
High-rise buildings typically generate a significant amount of wastewater due to the large number of occupants and various water-related activities. Traditionally, this wastewater is transported through an extensive network of pipes to large sewage treatment plants located on the ground, often outside the building premises. However, by installing compact sewage treatment plants within the high-rise building itself, several advantages can be achieved.The goal is to locate a compact sewage treatment plant (STP) in a 23-story high-rise structure in the most advantageous location.The analysis evaluates both the potential effects of the treatment plant on structural stability as well as the building's structural load-bearing capacity with the help of STAAD Pro.The study also examines the structural response to seismic activity after the placement of the treatment plant.

KEYWORDS: High Rise Building, Refuge Area, Shear wall, Seismic Analysis, STAAD Pro., Sewagetreatment plant.

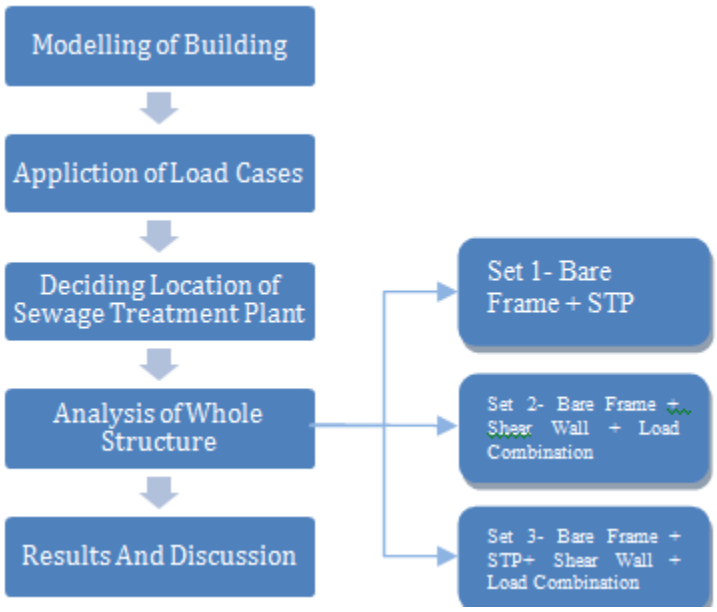
I. INTRODUCTION

The lack of space for a sewage treatment plant in high rise buildings can be a major problem. Also, the close proximity of the buildings to each other can make it difficult to find a suitable location for the plant. The current infrastructure in most high-rise buildings is not equipped to handle the amount of waste produced by the inhabitants. This often results in sewage being released into the environment, which can pollute waterways and cause health hazards.

There are several ways to address this issue, such as retrofitting existing buildings or constructing new ones with the necessary infrastructure. However, these solutions can be costly and may not be feasible for all buildings. Another option is to use some parts of refuge areas in high-rise buildings for installing sewage treatment plants. This would allow for proper treatment of waste while also taking emergency purpose in consideration.

However, there are some challenges that need to be considered when implementing this solution, such as ensuring that plant will not hamper the stability of structure and that it does not become a nuisance for nearby residents.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252



II. METHODOLOGY

A G+23 floor building with a plan area of 476.20 m^2 as shown in figure 1 with a cross-section of (24.61m x 19.35m). The compact sewage treatment plant to be accommodated in the refuge area. The analysis result of the building with this compact sewage treatment plant was compared with a building of same physical properties, but just without the compact sewage treatment plant provided with base isolation, to check the feasibility of the building towards structural responses.

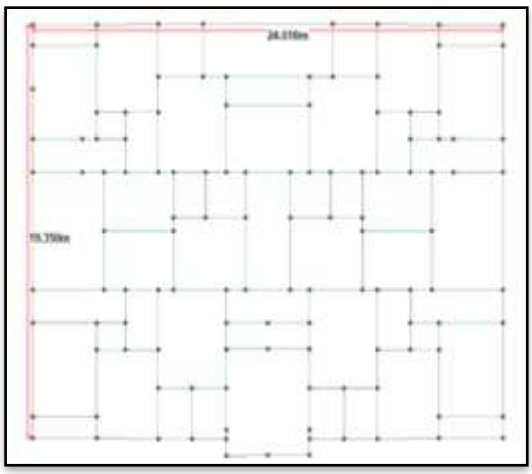


Fig. No. 1-Plan of Structure

2.1 Analysis Assumptions

Column Size -0.45 m x 0.25m
Beams Size - 0.35 m x 0.25m
Slab Thickness - 0.15 m
Shear Wall Thickness -0.15mm
Storey High -3.35m
City- Pune
Seismic Zone – III

2.2 Calculation of Loads

1. Dead load Calculations:
Unit Weight of Concrete=25 kN/m^2
2. Live Load Calculations:
L.L.= -2.5 kN/m^2on each floor
(Minus "-" sign indicates its acting on thedownward direction)
3.Wind Load Calculation: AS PER IS 875 PART3
4.Seismic Load Calculation: AS PER IS 1893-2016

2.3 Location of Sewage Treatment Plant

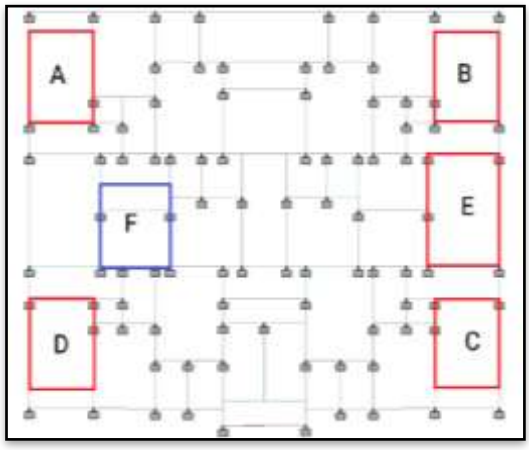


Fig.2 (Different locationsofSewageTreatment Plant)

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252

The capacity of the sewage treatment plant was carried out as per the requirement from flats located above the refuge area. Six different locations were considered for the Sewage Treatment Plant, as depicted in Figure 2

The SET 1 (Bare Frame + STP loading) undergoes analysis, and the corresponding nodal displacements are determined.

STP Loading at Location	X - Translation	Y - Translation	Z - Translation
A	-0.003	-0.017	-0.001
B	0.002	-0.017	-0.002
C	-0.003	-0.014	0.001
D	0.003	-0.017	0.001
E	0.003	-0.017	-0.000
F	0.001	-0.006	-0.000

Table No. 1 – Results of Nodal Displacement at various location

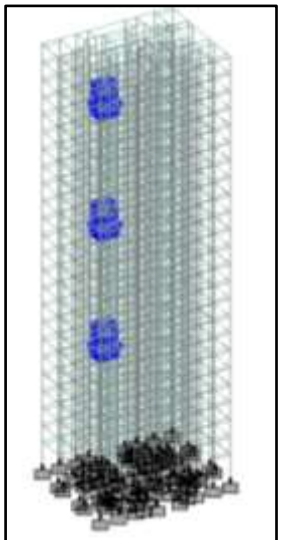


Fig No. 3 - Sewage treatment plant loading at Location F

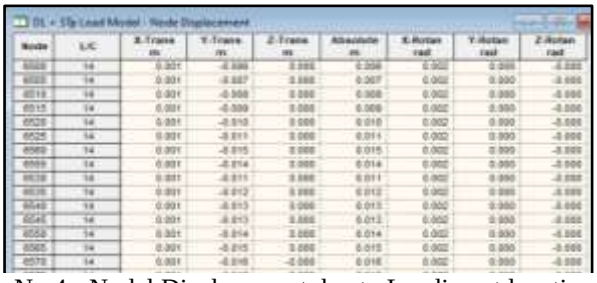


Fig No.4 - Nodal Displacement due to Loading at location F

By Referring Table No.1,The Nodal Displacement of the Sewage Treatment Plant at Location F is found to have the least displacement. As a result, this location has been selected and will undergo further analysis.

2.4 Addition of Shear Wall

Shear wall has been added to Lift Ducts and Staircase.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252

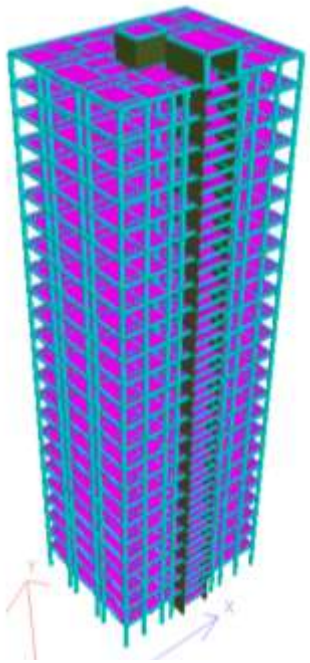


Fig. No.4 – Addition of Shear Wall

2.5 Load Combination

Details of loading:
1)DL- Dead load
2)LL – Live Load
3)WLX – Wind Load in X Direction
4)WLZ – Wind Load in Z Direction
5)EQX – Earthquake Load in X Direction
6)EQZ - Earthquake Load in Z Direction

Following are the loading combination considered.
Combination 1 :- 1.5(DL+LL)
Combination2:-1.2(DL+LL+WLX) Combination3 :- 1.2(DL+LL-WLX)
Combination 4 :- 1.5(DL+WLX)
Combination 5 :- 1.5(DL-WLX)
Combination 6 :- 1.5(DL+WLZ)
Combination 7 : 1.5(DL-WLZ)
Combination 8 - 1.5(DL+EQX)
Combination 9: - 1.5(DL-EQX)
Combination 10:- 1.5(DL+EQZ)
Combination 11:- 1.5(DL-EQZ)
Combination 12 :- 1.2(DL+LL+EQX)
Combination13 :- 1.2(DL+LL-EQX)
Combination 14:-1.2(DL+LL+EQZ)
Combination 15 :- 1.2(DL+LL-EQZ)
Combination 16 :- 0.9DL+1.5EQX
Combination 17 :- 0.9DL-1.5EQX
Combination 18 :- 0.9DL+1.5EQZ
Combination 19 :- 0.9DL-1.5EQZ

Set 2 (Bare frame +Shear wall+ Load Combination) and SET 3(Bare frame +Shear wall+ STP+Load Combination), Both the Sets are analysed and compared for their structural response.

III. RESULTS AND DISCUSSION

Load Combination	X-Translation (Without STP) m	X-Translation (With STP) m	%Increase in Translation
1	0.013	0.014	7.69
2	0.08	0.087	8.75
3	-0.068	-0.074	8.82
4	0.013	0.014	7.69
5	0.094	-0.104	10.64
6	-0.097	-0.104	7.22
7	-0.097	-0.104	7.22
8	0.099	0.112	13.13
9	-0.094	-0.107	13.83
10	-0.020	-0.023	15.00
11	0.029	0.033	13.79
12	0.083	0.097	16.87
13	-0.068	-0.078	14.71

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252

14	0.018	0.021	16.67
15	0.029	0.033	13.79
16	0.091	0.110	20.88
17	-0.09	-0.107	18.89
18	-0.021	-0.025	19.05
19	0.026	0.031	19.23

Table No.2-Comparison of Nodal Displacement for X-Translation

From Table 2, It is observed that the nodal displacement for loading combination 8 "1.5(DL+EQX)"in X translation shows the highest magnitude when subjected to an STP load, resulting in a 13.13% increase compared to the case without the STP load.
Also, the load combination 16 "0.9DL+1.5EQX" has highest percentage increase i.e., 20.88%.

Load Combination	Y - Translation (Without STP)m	Y – Translation (With STP) m	% Increase in Translation
1	-0.017	-0.018	5.88
2	-0.017	-0.018	5.88
3	-0.021	-0.023	9.52
4	-0.014	-0.016	14.29
5	-0.027	-0.030	11.11
6	-0.028	-0.030	7.14
7	-0.021	-0.023	9.52
8	-0.013	-0.015	15.38
9	-0.013	-0.015	15.38
10	-0.019	-0.022	15.79
11	-0.006	-0.007	16.67
12	-0.015	-0.017	13.33
13	0.013	0.015	15.38
14	-0.022	-0.025	13.64
15	-0.006	-0.007	16.67
16	-0.007	-0.009	25
17	-0.008	-0.009	12.5
18	-0.014	-0.016	14.29
19	-0.002	-0.002	0

Table No.3-Comparison of Nodal Displacement for Y-Translation

From Table 3, it is observed that the nodal displacement for loadcombination5"1.5(DL-WLX)"&6"1.5(DL-WLX)"in Y translation shows the highest magnitude when subjected to an STP load, resulting in a 7.14% &11.11% increaserespectivelyas compared to the case without the STP load.
Also, the load combination 16 "0.9DL+1.5EQX" has the highest percentage increase i.e. 25.

International Journal of Advances in Engineering and Management (IJAEM)
Volume 5, Issue 6 June 2023, pp: 646-652 www.ijaem.net ISSN: 2395-5252

Load Combination	Z – Translation (Without STP) m	Z – Translation (With STP) m	% Increase in Translation
1	-0.018	-0.019	5.56
2	-0.017	-0.019	11.76
3	-0.014	-0.016	14.29
4	-0.016	-0.018	12.5
5	-0.001	-0.001	0
6	-0.001	-0.001	0
7	-0.013	-0.014	7.69
8	-0.01	-0.011	10
9	-0.004	-0.005	25
10	0.076	0.086	13.16
11	-0.092	-0.105	14.13
12	-0.014	-0.016	14.29
13	-0.01	-0.012	20
14	0.051	0.059	15.69
15	-0.08	-0.092	15
16	-0.007	-0.008	14.29
17	-0.002	-0.002	0
18	-0.076	-0.089	17.11
19	-0.084	-0.102	21.43

Table no. - 4-Comparison of Nodal Displacement for Z-Translation

From Table 4, it is observed that the nodal displacement for loadcombination 11"1.5(DL-EQZ)"in Z translation shows the highest magnitude when subjected to an STP load, resulting in a 14.13% increase as compared to the case without the STP load.
Also, the load combination 19 "0.9DL-1.5EQZ" has the highest percentage increase i.e., 21.43%

IV. CONCLUSION

1. The strategic positioning of the sewage treatment plant (STP) at the centre of the building plan has significant implications. By being centrally located, the STP reduces nodal displacements, resulting in a more balanced distribution of loads across the structure. This is particularly critical for high-rise buildings, as it ensures the maintenance of structural stability and integrity.
2. Nodal Displacement due to load combination of dead load plus earthquake load has highest percentage increase when comparing SET 2 and SET3, which is around 20-25%.
3. The analysis reveals that the inclusion of the sewage treatment plant slightly increases the percentage of nodal displacement compared withthe scenario without the plant. However, these displacements remain within acceptable limits set by structural design codes and standards.

V. REFERENCES

Research Papers-

[1]. Dr. S. S. Angalekar ,Ganeshkumar S. Kharat , Et Al. "Response Analysis Of Effective Location And Positiong Of Waste Water Treatment Plant In High-rise Structure "
[2]. Dr. N.R.Dhamge, Pathan Irfan Khan "Review Paper On Seismic Analysis Of MultistoriedRcc Building Due To Mass Irregularity"
[3]. Bhattacharjee, J., Jain, P., & Gaurav, A. (2017).Study the behaviour of high-

risebuildings at different positions of shear walls subjected to seismicloading.
[4]. P.Prashanth&Anshuman.S (2012) - Comparison of design results of a Structure designed using STAAD Software, "International Journal of Engineering and Innovative Technology", volume no: 2, no of pages: 869 to 875.
[5]. Arunkumarpattar& Sunil kumarchavan (2015)- "Analysis and Design of Multi Storied Structural System with Wind Load Effects Using Staad Pro", international journal of innovative research in technology" volume no: 2, page no: 234 to 238

Books-
[1]. Duggal S.K (2010) "Earthquake resistance design of structure" Fourth Edition, Oxford university Press, New Delhi.
[2]. Shah V.L. and Karve S.R. (2010), Illustrated Design of Reinforced Cement Building Sixth Edition, Structures Publication, Pune

IS Codes: -
[1]. IS 875:1987 Code of Practice for Design of loads for building and structures.
[2]. IS 1893 (Part 1): 2016 Criteria for earthquake resistant design of structures.
[3]. National Building Code-2016(Part 4)- Fire and Life Safety.
[4]. IS 875 (Part 1) – 1987 for Dead Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 1100 02.
[5]. IS 875 (Part 2) – 1987 for Imposed Loads, Indian Standard Code Of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.
[6]. IS 875 (Part 5) – 1987 for Special Loads and Combinations, Indian Standard Code of Practice for Design Loads (Other Than Earthquake) For Buildings and Structures, Bureau of Indian Standards, Manak Bhavan, 9 Bahadur Shah Zafar Marg, New Delhi 110002.
[7]. IS 456-2000, Indian standard code of practice for plain and reinforced concrete standards, New Delhi.