Comparative Evaluation of Structural Design of STP For Western Central Railway At Jabalpur By WSM And LSM

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Abstract- *In this thesis document, Comparative analysis of the design of sewage treatment plant at jabalpur , for Western Central Railways, by Working Stress Method and Limit State Method, The study was conducted to compare the design provisions for IS 3370- 1965 and IS 3370-2009.The components of Sewage Treatment Plants have been designed by using Working Stress Method (IS 3370-1967 and IS 3370-2009) and Limit State Method (IS 3370-2009), and the changes incorporated due to the revision in IS 3370-1965 provisions have been studied and compared to the previous recommendations and specifications.*

For comparison, various components in the form of water retaining tank of different sizes have been designed by two methods; Working Stress Method, based on IS 3370-1965 , Working Stress Method, based on IS 3370- 2009 and Limit State Method, based on IS 3370-2009.For design, M30 grade concrete and Fe-415 grade steel has been used. The water tanks have been designed manually and the results from the two designs have been compared on various parameters and detailed structural drawings have been prepared and attached. Also,

The research has shown that for a given section, the Limit State Method (IS 3370-2009) was found to be the most economical whereas the Working Stress Method (IS 3370-2009) was found to be somewhat expensive for the design of sewage treatment plant's tanks when compared to the Working Stress Method (IS 3370-1965).

I. INTRODUCTION

90% of sewage is water transporting household wastes from the kitchen, bathroom, laundry, and night soil. They are partially dissolved in solution. The remainder enters a suspended or colloidal phase. Moreover, it includes salts from sweat, urine, laundry, bathing, and cooking. Also, it includes aquatic pathogenic organisms that have already been infected people's night soil. Table includes information on the concentrations.

Parameters		Range			
1	Biochemical oxygen demand, BOD	45-54			
2	Chemical oxygen demand, COD	1.6-1.9 times BOD			
3	Total organic carbon, TOC	0.6-1.0 times BOD			
4	Total solids, TS	170-220			
5	Suspended solids, SS	70-145			
6	Grit (inorganic,0.2 mm and above)	5-15			
7	Grease	10-30			
8	Alkalinity as calcium carbonate ($CaCO_3$)	20-30			
9	Chlorides	4-8			
10	Total nitrogen N	6-12			
11	Organic nitrogen	~0.4 total N			
12	Free ammonia	~0.6 total N			
13	Nitrate	~0.0-0.5 total N			
14	Total phosphorus	~0.6-4.5			
15	Organic phosphorus	~0.3 total P			
16	Inorganic(ortho- and poly-phosphates)	~0.7 total P			
17	Potassium(as potassium oxide K_2O)	2.0-6.0			
Microorganisms in 100 ml of sewage					
18	Total bacteria	10^9-10^{10}	22	Protozoan cysts	Up to 10^3
19	Coliforms	10^9-10^{10}	23	Helminthic eggs	Up to 10^3
20	Faecal streptococci	10^5-10^6	24	Virus (plaque forming units)	10^2-10^4
21	Salmonella Typhosa	10^1-10^4			

PROCESS INVOLVED IN SEWAGE TREATMENT:

Several methods can be used to treat sewage. Several types of treatment processes include:

(i) Preliminary treatment
(ii) Primary treatment
(iii) Secondary (or Biological) treatment
(iv) Final treatment

STRUCTURAL ASPECT OF SEWAGE TREATMENT PLANT

Wastewater treatment plants contain various infrastructure, including wastewater bins and tanks, clarifiers and covers. These products, which also include products designed to maintain that infrastructure, will help treatment plant operators make sure their plants are in top condition.

The waste water treatment plant in this case includes number of water storage bins/tanks, usually rectangular in shape. Some tanks are located underground, some are on-ground and some tanks are constructed over an elevated stage to maintain the desired flow.

The circular tanks are uneconomical to use for lesser capacity, and their form work is expensive. When a tank with a smaller capacity is needed to contain the liquid, rectangular tanks are advised. The rectangular tanks could be buried or lying on the surface. These tanks are recommended to have square layouts, and if that is not possible, it is preferred that the ratio of larger side to smaller side not exceed two.

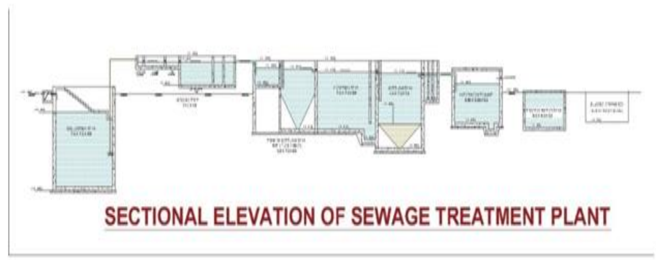
When a rectangular tank is underground, its walls are subjected to internal water pressure as well as earth pressure coming from the other side. Since the moments in a rectangular tank are induced in two directions, it is typically challenging to estimate correct analysis, hence approximate design methods are recommended. Tank walls of rectangular shapes are designed as continuous walls that are subject to pressure varying from minimum (zero) at the upper part to maximum at H/4 or 1 metre from the base whichever is more, as recommended by the code. For tanks where the ratio of length to breadth is less, containers either laying on the ground or raised are exposed to hydrostatic weight from inside than 2. whatever is greater.The bottom H/4 or 1 mis intended to be used with a cantilever. Because of the hydrostatic weight on the opposite side partitions, the dividers are moreover subject to coordinate strain. The long partitions are designed as cantilevers for the best view of Wh3/6 and the short partitions are pieces supported on the long partitions for rectangular partitions with a length to expansiveness ratio greater than 2. Planning calls for a cantilever range from base H/4 or a short divider of 1 m, whichever is greater. Also, the immediate strain brought on by weight on various partitions should be taken into consideration in this, and assistance should be provided. Tank walls might further be designed as follows when they are open at the top –

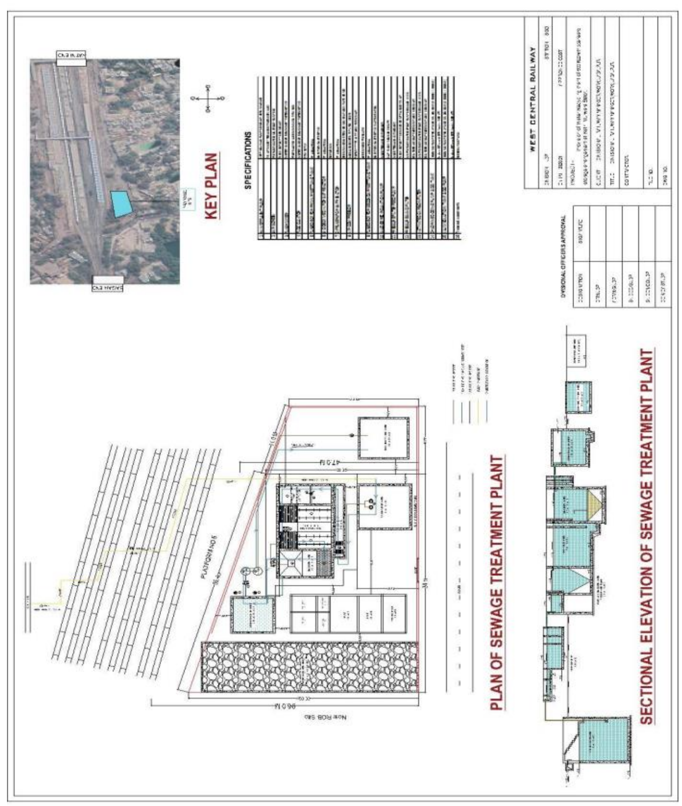
(a) All the dividers spreading over on a level plane as sections.
(b) All the dividers as cantilevers

Clear water repositories, settling tanks, air circulation tanks, and other types of reservoirs are all used with tanks that rest on the ground. These tanks' bulk is exposed to water weight from the inside, while the base is exposed to soil pressure and water weight as a result of response from beneath the base. The top of the tank may or may not be covered. A substantial amount of water can be kept aside in storage and used during peak demand cycles.

OBJECTIVES

1. To compare the RCC design of sewage treatment plant for INDIAN RAILWAYS, located at Jabalpur with below mentioned data done by WSM & LSM in reference to IS 3370 – 1965 and IS 3370 – 2009 (new version).
2. To analyze which method is more economical and efficient.





II. LITERATURE REVIEW

Indian Standards for the design of liquid retaining structures has been revised in recent times revised. This newly revised edition incorporated limit state design method. Limit state design method for water retaining structures was not adopted so far as liquid retaining structures should he crack free**.**Limit state method which is widely used has been prescribed in the new version of IS 3370-2009**.** This revised version of Indian Standards allows limit state method mainly considering two aspects. Limiting the stresses in steel so that concrete is not stressed above the specific point and in the second aspect it restricting the cracking width. It has been observed that Design of water tank by Limit State Method is most cost-effective as the quantity of material requisite is less as compared with working stress method.

III. METHODOLOGY

The elements of the sewage treatment plant are designed as rectangular water tanks resting on-ground, underground, partially underground and elevated, by the below mentioned three methods as per the provisions of IS 3370:1967 and IS 3370:2009. The quantities of steel required and concrete for each members adopting different design method have been calculated and presented in Tabular as well as graphical form.

Following IS: 3370 we have the following four methods of designs :

1. Working stress method , IS 3370 (1965).
2. Working stress method ,IS 3370 (2009).
3. Limit state design method by limiting steel stresses in accordance IS 3370 (2009).

COMPARISON OF IS: 3370-1965 & IS: 3370-2009

The revisions in IS 3370 (2009) include a number of important amendments. Few are stated as follows-

- Scope has been clarified further by mentioning exclusion of dams, pipes, pipelines, lined structures & damp proofing ofbasements.
- A clause on exposure condition has beenincluded.
- Regarding method of design Limit State Design or Working Stress Design can be adopted.
- A clause on durability has been included giving due reference to IS 456 in place of earlier clause on protection againstcorrosion.
- Provision of crack width calculations due to temperature and moisture has been incorporated in limit statedesign.

IV. PROBLEM FORMULATION

For this work, RCC tanks for sewage treatment plant with following heads considered.

(a) Collection Tank (7mx7mx6m, Underground Square tank)
(b) Grease Trap (11.4mx1.5m Underground Square tank)
(c) Primary Settling Tank (3.6m x 7.5m x 6.5m Partially Underground Tank)
(d) Aeration Tank (7mx7mx6.5m, Partially Underground Tank)
(e) Settling Tank (4.3mx7mx7m, Partially Underground Tank)
(f) Intermediate Sump (5.66mx5.66mx5, Partially Underground Tank)
(g) Treated Water Tank (6mx6m63m, Underground Tank)
(h) Sludge Drying Bed (28.4mx7.9m 2.1m, Underground Tank)

The tanks is designed with Working Stress Method and Limit State Method. The staging of elevated tank is designed by STAADPRO and STAADRCDC. A thorough study through both the versions of IS:3370 reveals the following four methods of designs:

1. WSM in accordance with IS 3370 (1965).
2. WSM in accordance with IS 3370 (2009).

LSM and then checking cracking width by limit state of serviceability in accordance with IS 3370 (2009).

V. DESIGN PARAMETERS CONSIDERED

Loading :

1. Dead load
2. Hydrostatic load
3. Seismic load
4. Wind load

Other parameters

1. Seismic zone : zone iii
2. Basic wind speed : 47 m/s
3. Soil type : soft soil (black cotton soil)
4. Safe bearing capacity : 60 kn per square meter.

Important indian standard design codes referred

1. Is 456:2000 *plain and reinforced concrete - code of practice*
2. **Is 3370:2009 (part 1)** code of practice concrete structures for the storage of liquids: general requirements.
3. **Is 3370:2009 (part 2)**: code of practice concrete structures for the storage of liquids, : reinforced concrete structures
4. **Is 13920** (1993, reaffirmed 2008): ductile detailing of. Reinforced concrete structures subjected to seismic forces
5. **Is 875 (part 1) :** code of practice for design loads (other than earthquake) for buildings and structures
6. **Is 875 (part 3) :** wind loads on buildings and structures.
7. **Is 1893 :2002** : criteria for earthquake resistant design of structures

VI. RESULT

					WORKING STRESS METHOD				LIMIT STATE METHOD						
S.NO.	PARTICULAR	L	B	D	THICKNESS	VERTICAL REINF.	VERTICAL REINF.	HORIZONTAL REINF.	THICKNESS	HORIZONTAL REINF.	HORIZONTAL REINF.	VERTICAL REINF.	BASE THICKNESS	REINFOR-X	REINFOR-Y
1	COLLECTIO	7	7	5	450	T12@100	T12@200	T12@150	230	T12@150	T12@300	T12@200	400	T12@175	T12@175
2	GREASE	6.9	1.5	2.5	450	T12@150	T12@150	T12@150	300	T12@150	T12@150	T12@150	350	T12@150	T12@150
3	GREASE	1.5	2	1	230	T12@225	T12@225	T12@225	230	T12@300	T12@300	T12@200	300	T12@150	T12@150
4	primary	7	3.6	5.75	450	T12@100	T12@200	T12@150	230	T12@200	T12@200	T12@200	400	T12@175	T12@175
5	AREATION	7	7	4.75	450	T12@150	T12@175	T12@150	200	T12@200	T12@200	T12@200	400	T12@175	T12@175
6	settling tank	7	4.2	6.18	450	T12@100	T12@150	T12@150	230	T12@200	T12@200	T12@200	400	T12@175	T12@175
7		5.66	5.66	5	450	T12@100	T12@200	T12@150	230	T12@300	T12@300	T12@200	400	T12@175	T12@175
8	SLUDGE	28.4	7.9	2.1	230	T12@175	T12@175	T12@150	200	T12@200	T12@200	T12@200	400	T12@175	T12@175

VII. CONCLUSIONS

The permissible stress and minimum reinforcement provision in both IS code has been compared, and then the design is done by Working Stress Method (IS 3370 1967), Working Stress Method (IS 3370 2009) and Limit State Method (IS 3370 2009) separately. After the complete design we get the result which shows that-

- The minimum thickness required for tank wall was found maximum in WSM (IS 3370:1967), but decreased in tank designed by WSM (IS 3370:2009). Furthermore, it was found minimum in the tank designed by LSM (IS 3370:2009)
- The reinforcement in corners of long wall of the tank was found increasing by 12.23% , when designed by WSM (IS 3370:2009), but decreased by 41.48% when designed by LSM (IS3370:2009).
- The reinforcement in mid span of long wall of the tank was found increasing by 11.85% , when designed by WSM (IS 3370:2009), but decreased by 43.86% when designed by LSM (IS3370:2009)
- The vertical reinforcements, designed for cantilever action in long wall of the tank was found increasing by 73.33% , when designed by WSM (IS 3370:2009), as well as LSM (IS3370:2009)
- The reinforcement in corners of short wall of the tank was found increasing by 15.5% , when designed by WSM (IS

3370:2009), but increased by 55.20% when designed by LSM (IS3370:2009).

- The reinforcement in mid span of short wall of the tank was found increasing by 11.9% , when designed by WSM (IS 3370:2009), but decreased by 65.24% when designed by LSM (IS3370:2009)
- There was no change observed in the thickness required of the base slab in both the Working Stress Methods , but it increased by 33.33% in Limit State Methoddesign.
- There was an increase of 16.6% in the reinforcements provided in base slab after the amendments in IS3370,
- Limit State Method was found to be most economical for design of water tanks as the quantity of steel needed is less as compared to working stress methods of both the IS codes i.eIS 3370 (1967) and IS 3370(2009).

REFERENCES.

[1] Reetika Sharan et.al [1] Design and Analysis of Overhead Water Tank at Phule Nagar, Ambernath
[2] R.N Mulani et.al [2] Comparison and design of water tank rest on ground by Lsm and wsm – a review
[3] Satheesh V.S. (2016) [7] Analysis and economical design of watertanks.
[4] Sanjay Bhadke et. al (2016) [5] Comparative study of design of water tank with new provisions
[5] Prasad S. Barve, Ruchi Barve (2015) [10] Effect of Variation of Diameter to Height (D/H) Ratio on