International Journal of Engineering Science Invention
ISSN (Online): 2319 – 6734, ISSN (Print): 2319 – 6726
www.ijesi.org ||Volume 6 Issue 10|| October 2017 || PP. 14-18

Comparative Analysis of Codal Provisions of IS: 1893- 1984 And IS: 1893 – 2014 (Part – 2)

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Abstract: *The present study concentrate on profound review of clauses related to liquid retaining structures as per fifth and fourth revisions of IS: 1893. Liquid retaining structures are useful to store water and other liquids like chemical, industrial products etc., .Failure of such structures during earthquakes may lead to economic loss as well as human loss. Especially water tanks are necessary to store large quantity of water supply for public utility. They may fail because of increasing in intensities earthquake day by day due to changes in earth crust from increase in population and construction activity. Failure of water tanks during earthquake may endanger basic needs of civilization. Hence the present paper aims to enumerate and study the difference between fourth revision (IS: 1893-1984) with fifth revision IS 1893- 2014 (Part-2). The review concentrates on specifications of liquid retaining structures focusing on hydrodynamic pressure, convective, impulsive pressure, sloshing wave effect, staging, tank type condition, base shear, base moment and deflection. Based on the detailed discussions the positive aspects can be possible to incorporate in the Fifth revision.*

Keywords: *Base shear, Base moment, sloshing wave, water tanks*

Date of Submission: 22-09-2017 Date of acceptance: 09-10-2017

I. Introduction

Liquid retaining structures are useful to store water and other liquids like chemical, industrial products etc.,.The various material used for construction of water tanks are stone, fiberglass, concrete, steel and plastic material like polyethylene, polypropylene, polyvinylchloride are used during construction of water tank. The storage water is useful for the drinking purpose and irrigation, agriculture, farming and both for livestock and plants. Water is human basic need for daily life which is generally stored in tanks. The water can be stored in underground, ground supported and elevated tanks. Classification of elevated tanks can be two types that are based on shape of container and supporting system. Based on shape of the container elevated water tanks can be classified as Square tank, Rectangle tank, Circular tank and Conical tank and Intze tank. Based on supporting system elevated tanks can be classified as Shaft supported elevated tank and Trestle supported elevated tank.

During earthquake a large number of elevated water tanks are severely damaged where as others tanks survives without any damage [1]. The damage may be due to sloshing wave effect, staining, which can be minimize by predicting appropriate seismic force and its effects. The seismic safety for liquid storage structure is very much important. This structures need to design in such a way that they remain functional even after an earthquake too. The industrial liquid storage tanks may contain highly toxic and inflammable liquids and those tanks should not loss their material during earthquake resulting in economic loss.

The effect of earthquake can be predicted as seismic force onto the water tanks, by following prescription of IS 1893:1984[2](fourth revision). This code has specified clauses for seismic force design related to many structures like buildings, dams, retaining walls, chimney and water tanks etc.,. The fifth revision IS 1893- 2014 (Part-2) [3] has given inputs exclusively for liquid retaining structures and its various design aspects.

In the present research IS: 1893- 1984(Criteria for earthquake resistant design of structures (Fourth Revision)) [2] is compared with IS 1893- 2014 (Part-2)(Criteria for earthquake resistant design of structures: Part2 Liquid Retaining Tanks (Fifth Revision)) [3]. The comparison mainly focused on specific parameters like Base shear, Base moment, Hydrodynamic pressure, Sloshing wave, Staging, Anchorage requirement, Zones.

II. Literature Review

P.L.N. Sarojaetal [4] studied the analysis of the elevated water tank and comparing the forces on elevated water tank in different seismic zones due to earthquake. The analysis is done by using codebook of

IS1893 (part-2) 2002[5]. From study they concluded that the forces acting on the elevated water tank due to seismic forces are calculated for all the zones and the base shear, base moment values are compared from zone I to zone IV. Horizontal forces due to seismic and wind effect are also calculated. Hence the design has to be done by using tank full condition.

P.MuthuVijay and Amar Prakesh etal [1] studied the effect of sloshing impact on overhead liquid storage tank. In such structure a large mass concentrated at the top of slender supporting structure vulnerable to horizontal forces. The analysis and design of the elevated intze water tank is done by using STAAD – PRO [6]. From study it is concluded that, to consider the sloshing effect along with the effect of hydrodynamic pressure on container wall of the tank during the design is very important in earthquake prone regions.

AkshayaB.Kamdi and Prof.R. V.R.K.Prasadetal [7] studied the theory behind the design of circular water tank using working stress method and limit state method. The BIS has brought out the revised version IS3370 (PartI&II) after a long time from its 1965 version to revised version of 2009. The revised code is mainly drafted for water tank and they incorporated the limit state method in design. It mainly focused on analysis and design of circular cylindrical water tank by using IS 3370:1965[8] old codebook with IS 3370: 2009[9] new codebook. From study it is concluded that the thickness of wall and depth of base slab has been taken from codebook of IS 3370:1965 and IS 3370:2009 because of the value of the stress in steel .The design of water tank by limit state method is more economical as the quantity of material less as compared with working stress method.

OBJECTIVE & SCOPE OF STUDY

Liquid retaining structures like water tanks, oil wells, chemical storage tank etc., are necessary in modern days. Failure of such structures during earthquakes may lead to economic loss as well as human loss. Especially water tanks are necessary to store large quantity of water supply for public utility. Failure during earthquake may endanger basic needs of civilization. The predicted seismic force of earthquake and general specifications related to liquid retaining structures are specified in IS: 1893. Some part of IS: 1893-1984 (Fourth revision) [2] is revised to IS: 1893- 2014 (Part-2) (Fifth revision) [3] for liquid retaining structures.

The present paper gives a comparative emphasis on code provisions of fourth revision and fifth revision for liquid retaining structures. After comparison the outcome can be profound review on existing parameters like type of tank, base shear, base moment and hydrodynamic pressure. Further possible outcome can be an input to incorporated in the Fifth revision.

III. Methodology

Comparing IS 1893-1984(Criteria for earthquake resistant design of structures (Fourth Revision)) [2] with IS1893 - 2014 (Part-2) (Criteria for earthquake resistant design of structures: Part2 Liquid Retaining Tanks (Fifth Revision)) [3]. The present study concentrates on hydrodynamic pressure, convective, impulsive pressure, sloshing wave effect, staging, tank type condition, base shear, base moment and deflection.

IV. Results And Disscusion

Comparative Study- Analysis And Discussion

The detailed and necessary discussions on provision of fourth revision and fifth revision as follows:

Zones: As per fourth revision based on the recently occurred earthquakes and seismic data the zones are dividing into five zones. They are Zone-I, Zone-II, Zone-III, Zone- IV and Zone-V. As per the fifth revision the zones are dividing into Zone-II, Zone-III, Zone-IV and Zone-V.

Discussion**:** Earth's crust is affected by natural causes like tsunamis, volcanic eruption, landslides etc and human activates like dumping of nuclear waste in deep sea beds, digging earth for various purposes especially increase in population leading to increase in construction activity, non proportional increase in population. Due to which a lot of changes are occurring in the plate tectonic boundaries. Resulting in changing of seismic activity intensity in mother earth causing changes in the zones of earthquake in India. Due to increase in population and construction activity in India, least effected earthquake areas (Plate boundaries) are very minimal. Hence forth least affected areas of Zone I in previous code are transferred to other zones in Fifth revision.

Method of seismic design: The fourth revision suggested seismic coefficient method and response spectrum method for designing of liquid retaining structures from clauses 3.4.2.3. The fifth revision suggested seismic coefficient method given in the clause 4.5.

Discussion: Using Response spectrum method and seismic coefficient method water tanks can be designed. Though IS 1893 (Part-1) -2002[10] ruled out use of response spectrum method for buildings, IS 1893 - 2014 (Part-2) [3] fifth revision would have incorporated response spectrum method. Further Seismic coefficient method is static method of analysis which can be easily applied to analysis of water retaining structures.

Whereas dynamic analysis of liquid retaining structure is very complex. This is in good agreement with (Syed Saif Uddin) [11]. Hence code might have permitted to use seismic coefficient method for designing of water retaining structures.

Damping: As per the fourth revision the damping in the system assumed as 2% of critical for steel structures and 5% of critical for concrete structure is considered. Whereas from the fifth revision the damping in the convective mode all types of liquids and tanks is taken as 0.5% of the critical and the damping in impulsive mode is taken as 2% of the critical for steel tanks and 5% of the critical for concrete or masonry tanks.

Discussion: It gives closure results to reality.

Seismic coefficient: From the fourth revision the design value of Horizontal Seismic Coefficient (α_h) is computed based on Seismic Coefficient Method and Response Spectrum Method given in the clause 3.4.2.3. From the fifth revision the design value of horizontal seismic coefficient (A_h) is suggested given in clause 4.5.

Discussion: Horizontal Seismic Coefficient (α_h) is based on soil characterization in place of response reduction factor(R) in $A_{h.}$ Considering α_h only static load is applied. Whereas A_h is additionally affected by Response Reduction factor (R), which gives results based on equivalent lateral forces. This is quit reliable since dynamic factors in terms of R are taken into consideration simulating equivalent static load. Hence the results computed with A_h are more reliable make the complex analysis simpler.

Hydrodynamic Pressure: From the fourth revision calculation of hydrodynamic pressure is considered, the convective pressure for design of tank following clause 5.2.7. From fifth revision, the calculation of hydrodynamic pressure included the impulsive and convective pressure for analysis and design of tank as given in clause 4.9.

Discussion: Fourth revision considered hydrodynamic pressure of liquid and considered the earthquake effect as convective and impulsive pressures. That is dynamic effect of earthquake on liquid retaining structure and sloshing wave effect. Further it neglected the impulsive effects considering them to be negliable.

Later many researchers [P.Muthu Vijay, Amar Prakeshetal,][1]analyzed liquid retaining structures and identified that the effect of sloshing wave is predominant. Hence Fifth revision has considered sloshing wave effect separately but not as a hydrodynamic pressure as in case of fourth revision. In Fifth revision effect of sloshing wave due to earthquake on liquid is taken as convective pressure and considered its effects in analysis. In addition the impulsive pressure is taken into account due to the effect of earthquake on water retaining structure as a whole.

Mass Idealization: The fourth revision based on the single degree of freedom idealization (mass). And the fifth revision based on the two degree of freedom idealization for design of liquid retaining structures.

Discussion: Fourth revision considered single mass model which is mass from hydrodynamic pressure of liquid in addition to the self weight of the water tank structure. This system is solved as a single degree freedom for a single mass idealized system. 1/3rd of staging mass is being considered for design. Fifth revision has a two mass idealization system considering sloshing wave effect separately but not as a hydrodynamic pressure as in case of fourth revision. In this two mass model which is which reality being close to idealized as a convective mass (m_c) which is attached to the tank wall by spring with stiffness (k_c) and impulsive mass (m_i) is rigidly attached to tank wall.

In case of elevated tanks mass1is convective mass (m_c) is mass of the liquid in top most layers. Mass 2 is impulsive mass (m_i) which includes mass of the tank plus 1/3rd mass of staging.

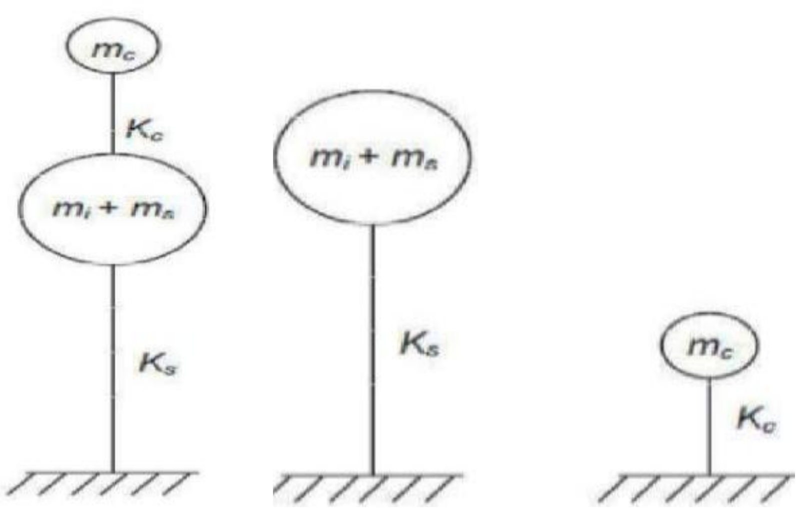

Fig. 1 Two mass idealization

Sloshing wave

Discussion: The clause 5.2.7.1 says that Sloshing wave effect can be neglected in the design of water tanks. The Fifth revision has incorporated its maximum effect.Clause 4.11has given the sloshing wave height for free board requirement under the effect of severe earthquake.

Base Shear & Base Moment: From the fourth revision the calculation seismic parameters such as Base shear, time period etc., are determined using single mode (Single degree of freedom idealization) for following clauses 5.2.3 and 4.2.11.Where as in fifth revision the seismic parameters such as base shear, base moment, time period etc., are determined using two modes such as convective and impulsive for following clauses 4.3.1, 4.3.2, 4.6and 4.7.

Discussion: Base shear, base moment may gives reliable results due to the two mass model idealizations and due to the considered more effects of dynamic parameters. In general seismic coefficient method results in lower seismic parameters such as base shear and base moment. From (SAROJAetal)[4] mention that the both base shear and base moment are reduced due to difference in the methods.

Mode shapes

Discussion: Two mass model (as per fifth revision) gives practical mode shapes reliable to oscillation of building when compared with single mass model (as per fourth revision) modes. Based on which structural stability can be improved with appropriate design considerations.

Types of Tanks: The fourth revision has given design procedure for elevated water tank only. Whereas the fifth revision has given design procedure for elevated water tank and included the design ground supported tank and buried tanks.

Discussion: In fourth revision, seismic design provisions for elevated tanks are provided. Whereas in fifth revision, provisions for seismic design of elevated tank is provided in detailed. A very scanty information on seismic design provisions for ground supported tanks and buried tanks are provided.

Tank Condition

Discussion: The clause 4.1 has given procedure for seismic analysis of water tanks in half full and empty conditions indirectly. That is it has mentioned to refer. There is no clarity because IS: 1893 (Part-1) doesn't contain any such conditions. And that to IS: 1893 (Part-1) 2002[10] or IS : 1893 (Part -1) 2016[12] is exclusively for seismic analysis of buildings but not water retaining structures. Danger will be for half full condition as identified from works (Saroja etal)[4].

Staging: Information about staging is provide in Clause 8.1 of fifth revision.

Discussion: Staging is very important supporting system whose failure may lead to damage of elevated water tanks. Fifth revision has mentioned in detail about staging with different materials. It didn't specify ductile detailing for RC staging. The code can concentrate more on the patterns of staging and its bracings (radial, hexagonal, cross) in combination with tank conditions.

Anchorage: From the fourth revision the calculation of anchorage requirement is not included. While coming to the fifth revision the calculation of anchorage requirement is considered given in clause 4.12.

Discussion: The provided anchorage is a additional support against creation of overturning moment ensuring structural stability of liquid retaining structures.

- Additional Discussion: Fifth revision didn't specify dynamic methods applied to analysis of liquid retaining structures. Design of ring beams is considered but detailed procedure is not mentioned. Special tank like intze tank design parameters and arbitrary shaped tank analysis is not mentioned. Analysis of buried tanks procedure is not discussed in detail. The Fifth revision didn't suggest any specific design codes like IS 800 [13],IS 1343 – 2012 [14] to design water tank with different materials like composite, plastic (polyethylene, polypropylene, polyvinylchloride), fiberglass, stone, steel etc.,. Fifth revision never specified safe position of water tank to be placed on building, in general it should be placed at centre for equal distribution of mass criteria.

Several parameters have been considered, for example, dynamic amplification of component relative to fundamental period of structure: redundancy, ductility and energy dissipation capacity of the element attachment to structures fifth revision.

Deflection and cracking: The old and Fifth revisions didn't suggest allowable deflection and permissible cracking values for different materials. Neither of them suggested to refer Indian standards such IS 800 [13], IS 1343 – 2012 [14] revisions to get the permissible values of cracking and deflection. Code didn't mention model solved examples.

Conclusion

After through revision on earthquake codes fourth revision (IS 1893-1984)[2] and fifth revision (IS 1893-2014(Part -2))[3] code the following conclusions are drawn:

1) The code adopted seismic coefficient method as equivalent load method may give good results. But code didn't give solved design examples.
2) The code didn't specify dynamic methods of analysis which may yield more practical results.
3) The code has considered two mass idealizations which may result in to reliable base shear and base moment with improved stiffness.
4) The code has incorporated dynamic effects of sloshing wave in the design of liquid retaining structures.
5) The code has incorporated the effect of convective hydrodynamic pressure.
6) Both codes didn't specify the clauses to design underground tanks.
7) For arbitrary shapes of tanks no special provision has been given.
8) Elasto plastic materials, Composite materials are not at all discussed in code.
9) The code never specified safe position of water tank to be placed on building.
10) The code has given clarity on preferred design of water tank condition such as full, half full and empty.
11) The code can concentrate more on the patterns of staging and its bracings (radial, hexagonal, cross) in combination with tank conditions.
12) Neither of them suggested to refer Indian standards such as IS 800[13], IS 1343- 2012 [14]revisions to get the permissible values of cracking and deflection.

Some of these conclusions may be considered to incorporate in the next code "Criteria for earthquake resistant design of structures: Part 2 Liquid retaining tanks".

References

[1]. P. Muthu Vijay, Amar Prakesh " Analysis of Sloshing Impact on Overhead Liquid Storage Structures", International Journal of Research in Engineering and Technology, Volume2, Issue 8, August 2014,127-142, ISSN(E): 2321-8843; ISSN(P):2347-4599.
[2]. IS: 1893- 1984 "Criteria for earthquake resistant design of structures", Bureau of Indian Standards.
[3]. IS1893- 2014 (Part-2) "Criteria for earthquake resistant design of structures: Part2Liquid Retaining Tanks", Bureau of Indian Standards.
[4]. P.L.N. Saroja (2016) "Comparative Study of Analysis of Elevated Water Tank due To Earthquake from Different Zones of Earthquake", International Journal of Constructive Research in Civil Engineering (IJCRCE), Volume 2, Issue 1, PP 22-29, ISSN 2454-8693.
[5]. Draft Code IS : 1893 – 2002 (Part-2) " Criteria for Earthquake Resistant Design of structure (Liquid Retaining Tanks)" , Bureau of Indian Standards.
[6]. "Structural Analysis And Design Computer ProgramSTAAD.Pro" Users manual, Computers and Structures, Bentley Systems.
[7]. Prof.R.V. R.K. Prasad, AkshayaB.Kamdi " Effect of IS 3370 ON Water Storage Tank", International Journal of Engineering Research and Applications (IJERA), Volume 2, Issue 5, September- October 2012, pp.664-666, ISSN: 2248-9622.
[8]. IS 3370 (Part-1&2&4): 1965 concrete structure for storage of liquid-code of practice.
[9]. IS 3370 (Part- 1& 2): 2009 concrete structure for storage of liquid-code of practice.
[10]. IS 1893 (Part-1) – 2002 " Criteria for Earthquake Resistant Design Of Structures - Part -1 General Provisions and Buildings", Bureau of Indian Standards.
[11]. Sayed Saif Uddin (2013) "International Journal of Advanced Trends in Computer Science and Engineering", Seismic Analysis Of Liquid Storage Tanks, Volume 2, No 1, Pages: 357-362, January.
[12]. IS 1893 (Part-2):2014 "Criteria for Earthquake Resistant Design of Structures"Bureau of Indian Standards.
[13]. IS 800:2007 General Constructions in Steel Code of Practice.
[14]. IS 1343: 2012 CodeofPracticeforPrestressedConcrete.

International Journal of Engineering Science Invention (IJESI) is UGC approved Journal with Sl. No. 3822, Journal no. 43302.

V.Vennela. "Comparative Analysis of Codal Provisions of IS: 1893- 1984 And IS: 1893 – 2014 (Part – 2)." International Journal of Engineering Science Invention(IJESI), vol. 6, no. 10, 2017, pp. 14–18.