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Seismic Analysis of Reinforced Beam-Column Connection for Intze Water Tank

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Abstract— **This paper presents, an analytical study carried out on intze water tank, by using Sap2000 v20 and Etabs using a linear dynamic analysis (Response Spectrum). In this project we are interested to check seismic behavior and to analysis the beam column connection using various approaches, pin connection, rigid connection and by using dampers to make design safe and economical.**

Keywords— **Dampers, Story drift, beam column connection, Response spectrum.**

1. INTRODUCTION

Water tanks are of various size and various types are constructed. And there are many different ways to store the water such as underground, ground supported, elevated water tank, and in various geometry, circular, rectangular, intze etc. Water tank has made our lives easy and complete our need. But as the evolution take place and considering the population the need water increase. So to compete the problem we have to came with new designs and with more solutions to problem. In this paper we are focusing on beam column connection of intze tank. Beam column connection is an important part of RCC concrete MRF subjected to seismic loading. Therefore it should not fail during earthquake activity. Among the diverse types of tanks used for water towers “Intze” tank is a very reasonable type for reinforced concrete water towers of large capacity, because of its ability to carry part of water load by direct compressive forces. Intze tank, a domed cover is provided at top with a cylindrical and conical wall at bottom. A ring beam will be required to support the domed roof. A ring beam is also provided at the junction of the cylindrical and conical walls. The conical wall and the tank floor are supported on a ring girder which is supported on a circular wall.

Analysis was done using SAP 2000. V20 and Etabs finite element software. Shell thin area element introduced for the roof dome, frustum cone, circular walls, intermediate slabs and bottom slab. Pin supports were applied as a support of the structure alone bottom of the supporting circular wall and foundation design was done separately.

Beam column joint is structurally weak when subjected to large lateral loads, which include wind loads, earthquake loads. Beam-column joint is the critical zone in a reinforced concrete frame structure. During its service life, it is exposed to considerable pressures and its action has a direct impact on the structural stability. While the designing of reinforced concrete structures, more attention is given to increase the compressive strength of basic structural elements like columns, beams, slabs. Comparatively, a beam-column joint becomes structurally less efficient when subjected to large lateral loads. Keeping this in view, In this project various approaches are carried out to make the design safe and economical of intze water tank, by using sap2000.

2. OBJECTIVES

1. In the present study, to model and design the intze tank by using software ETABS and SAP2000
2. To do the linear dynamic analysis of intze water tank.
3. To perform Response Spectrum analysis for the structure with rigid and semi rigid connections.
4. Seismic analysis of building
5. To give the preventive measures

3. LITERATURE REVIEW

The below literature survey includes summary of research papers presented in popular journals on topics similar to current field of study.

1] S. R. Uma, Sudhir K. Jain, Structural Engineering and Mechanics, Vol. 23, No. 5 (2006) 579-597 [1] presented a paper called “Seismic design of beam-column joints in RC moment resisting frames." The behaviour of reinforced concrete moment resisting frame structures in recent earthquakes all over the world has highlighted the consequences of poor performance of beam column joints. Large amount of research carried out to understand the complex mechanisms and safe behaviour of beam column joints has gone into code recommendations. This paper presents critical review of recommendations of well established codes regarding design and detailing aspects of beam column joints. The codes of practice considered are ACI 318M-02, NZS 3101: Part 1:1995 and the Eurocode 8 of EN 1998-1:2003. All three codes aim to satisfy the bond and shear requirements within the joint. It is observed that ACI 318M-02 requires smaller column depth as compared to the other two codes based on the anchorage conditions. NZS 3101:1995 and EN 1998-1:2003 consider the shear stress level to obtain the required stirrup reinforcement whereas ACI 318M-02 provides stirrup reinforcement to retain the axial load capacity of column by confinement. Significant factors influencing the design of beam-column joints are identified and the effect of their variations on design parameters is compared. The variation in the requirements of shear reinforcement is substantial among the three codes1]. 2] Neha. S. Vanjari,krutika. M. Sawant, Prashant .S. Sisodiya.Students. Vol 2, Issue 7, July 2017The water is the most essential element to a life on the earth. It is a liquid which covers about 71.4% of the earth. It is the most ubiquitous substance in the human body. The approximate consumption of water in a population of around 20,000 is 200 litres/head/day. The water is also important in the agricultural and industrial sectors. Water demand is one of the key issues in water supply planning. To overcome this issue, the present water tank designs have to be modified. Overhead water tank is the most effective storing facility used for domestic or even industrial purpose. The design and construction methods in reinforced concrete are influenced by the prevailing construction practices, the physical property of the material and the climatic conditions, linings, the ground conditions i.e. type of soil, soil bearing capacity etc. This paper gives an overall designing procedure of an Overhead Circular Intze tank using LIMIT STATE METHOD from IS-3370:2009. In IS-3370:2009, limit state method considering two aspects mainly limits the stress in steel and limits the cracking2].3]K.R.Bindhu.et.al. researched on a six storeyed building situated in zone –III where an exterior R.C beam column joint at transitional storey is depicted as per latest codal provisions from IS 1893 and IS 13920. These were tested under two different axial cyclic loads in which two specimens are detailed as per IS 456 and SP 34 and other two specimens under IS 13920. Tensile cracks are formed on all the specimens at interface of the beam and column which shows that strong column and weak beam state and the joints have some hairline cracks which exhibits the shear – resisting capacity of joints [3]. AnusreeLal regarded joint as a structural member where the bending moments and shear forces are large enough when compared to other elements. Considering the exterior joints is one of the failure zones, a G+2 building is prototyped in STAAD Pro VSi where the joint is modelled in ANSYS where the maximum deformation noted as 0.48 mm and shear stress is 4.27MPa which is in the allowablelimit.4]Francesca Feroldi.et.al. stated that moment rotation behavior of the joints is strongly influenced by the plates and bolted connections. The initial stiffness for each type of connection is determined in the experimental program where as numerical studies on pultruded plates and c-shape FRP profiles of bolted connections states that they have strong effect on the ultimate moment and rotation which is related to ultimate strength [4].

4. METHODOLOGY

Firstly, dimensions of the tank and size water is decided with considering the forecast population. Then modeling of intze water tank done in etabs as refers to above paper, In Etabs till now analysis and modeling of Intze water tank was not done. With this approach signifying and analysis is done. Various load cases has to apply on model like water load Hydrostatic load, which is still difficult to apply on vertical cylindrical walls. Simultantenously same work is carried out in sap2000 v20 for better results. Considering Seimic analysis of structure Basic plan of water tank for seismic loads is fundamentally concerned with secondary security among major ground movements, but serviceability and the possible for monetary disaster are too of concern. Seismic stacking requires an understanding of the basic execution beneath huge inelastic misshapenness. Behavior beneath this stacking is in a general sense diverse from wind or gravity stacking, requiring much more point by point investigation to guarantee worthy seismic execution past the versatile run. A few supporting harm can be anticipated when the building encounters plan ground movements since nearly all building codes permit inelastic vitality dissipation in basic frameworks. In common, for a multi story building it is necessary to require under consideration contributions from more than one mode. Separated from gravity loads, the structure will encounter overwhelming sidelong strengths of considerable greatness amid seismic tremor shaking

4.2. LINEAR DYNAMIC ANALYSIS RESPONSE SPECTRUM.

In order to perform the seismic analysis and design of a structure to be made at a particular location, the actual time history record is required. However, it is not possible to have such records at each and every location. Further, the seismic analysis of structures cannot be carried out simply based on the peak value of the ground acceleration as the response of the structure depend upon the frequency content of ground motion and its own dynamic properties. To overcome the above complications, earthquake response spectrum is the most popular tool in the seismic analysis of structures. There are computational benefits in using the response spectrum method of seismic analysis for prediction of displacements and member forces in structural systems. The method involves the calculation of only the maximum values of the displacements and member forces in each mode of vibration using smooth design spectra that are the average of several earthquake motions. This chapter deals with response spectrum method and its application to various types of the structures. The codal provisions as per IS:1893 (Part 1)-2002 code for response spectrum analysis of multi-story building.

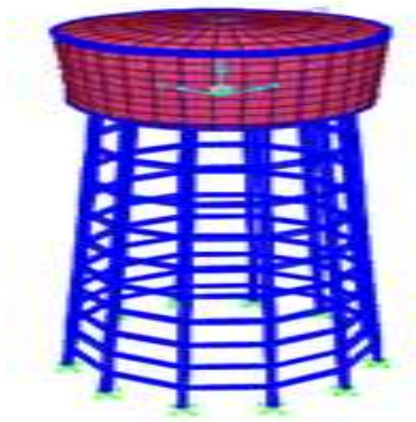

Fig.1 Isometric view of Intze water tank in Sap2000 v20.

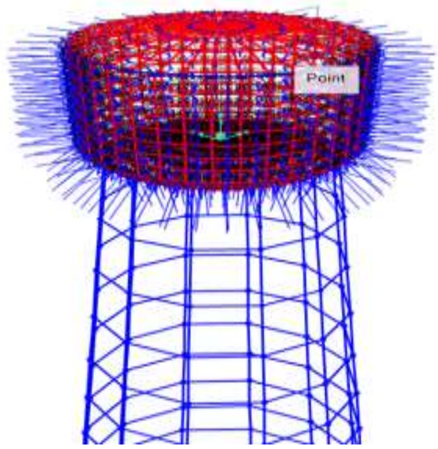

Fig. 2 Hydrostatic water load in Intze water tank in Sap2000 v20.

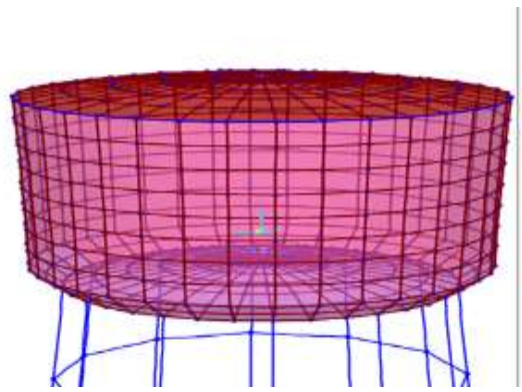

Fig.3 Deformation of shell structure of Intze water tank in Sap2000 v20.

5. SAP2000 V20 MODELING

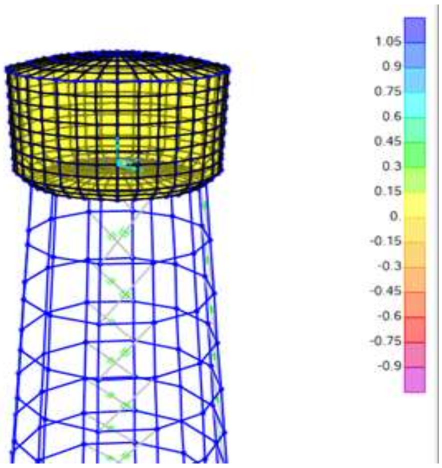

Fig.4 Intze water tank with Viscous fluid dampers.

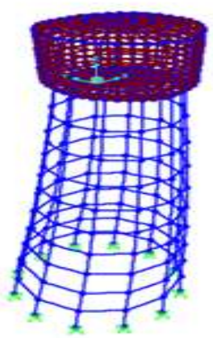

Fig.5 Seismic Loading.

6. ETABS 2016 MODELING.

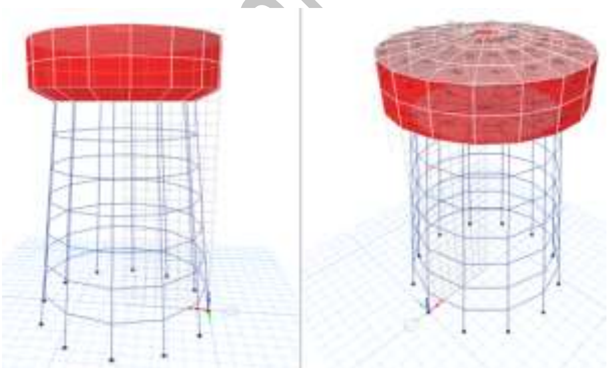

FIGURE 6 : Intze water tank In Etabs modeling.

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7.0 MODELLING OF STRUCTURE AND PARAMETERS

HYSD Fe 415 bars

Thickness of top dome = 100mm

Thickness of side wall = 150mm

Thickness of bottom dome = 200mm

Let diameter of ring beam = B2 = Do= 7.62

Diameter of cylindrical portion D = 9.14 m

R = 4.5 m H = height of tank = 5 m

8. RESULT AND DISSCUSSION

All the types of structure are analyzed using the software ETABS 2016 and SAP2000 V20. The obtained results of each building are tabulated and explained as follows:

9. BASE REACTION

Following are the results obtained for the base reaction in terms of base shear, joint displacement, joint acceleration and story drift. The obtained results are shown in tabulated form. From the results it seems that the displacement and story drift is minimum in case of dampers.

TABLE 9.1 : COMPARISON

NO.	ITEM	WITHOUT DAMPERS MAX	WITH DAMPERS MAX
1	BASE SHEAR	1222.064 KN	178.35 KN
2	JOINT ACCLERATION	1.46g	0.083g
3	JOINT DISPLACEMENT	216.59mm	18.25mm

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TABLE: 9.2 MAX STORY DRIFT WITH OUT DAMPERS

Level	U1	Dist	Drift
12	191	2.5	-4.4
11	202	2.5	-5.6
10	216	3.048	0.32808399
9	215	3.048	2.624671916
8	207	3.048	3.608923885
7	196	3.048	4.248687664
6	183.05	3.048	5.708661417
5	165.65	3.048	7.654199475
4	142.32	3.048	10.17716535
3	111.3	3.048	12.84448819
2	72.15	3.048	14.34383202
1	28.43	3.048	9.327427822
Base		0	0

TABLE: 9.3 MAX STORY DRIFT WITH DAMPERS

Level	U1	Dist	Drift
12	17.26	2.5	-0.168
11	17.68	2.5	-0.228
10	18.25	3.048	0.068898
9	18.04	3.048	0.419948
8	16.76	3.048	0.644357
7	14.796	3.048	0.543307
6	13.14	3.048	0.295276
5	12.24	3.048	0.396982
4	11.03	3.048	0.354331
3	9.95	3.048	0.331365
2	8.94	3.048	1.391076
1	4.7	3.048	1.541995
Base			0

10. SUMMARY AND CONCLUSION

In this study we analyze a Intze water tank structure for seismic analysis and also a linear dynamic analysis.

1. In case of base shear damper model performs well.
2. Etabs need to be develop more in tools of hydrostatic load cases.
3. Provision of pin connection in beam column frame shows better result.
4. In all cases joint displacement is maximum for the rigid connection.

Beam-column joints in moment resisting frames have conventionally been ignored in design process while the separate connected elements, that is , beams and columns, have received significant attention in design. Research on beam-column joints of reinforcement concrete moment resisting frame was ongoing only in the 1970s. The 1993 version of IS 13920 : 1993 incorporated some provisions on the design of beam-column joints3 . However, these provisions are insufficient to prevent shear and bond failure of beam-column joints in severe seismic shaking. Therefore, these provisions need to be promoted substantially with addition of plain provisions on shear design and anchorage requirements. This article proposes provisions for shear design of beam-column joint and anchorage requirements of tension beam bars in the joint area. It also suggests provisions for the confinement of wide beam and column connections. A solved design example has been provided to explain these requirements for an interior beam-column joint. In the solved example it was seen that the joint fails in shear for design earthquake shaking in both x and y directions. The joint can be redesigned by increasing size of column, size of beam, or grade of concrete. In this example, however, the increase of size of column and depth of beam are sufficient to satisfy the shear strength requirements.

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