Comparative Analysis of Beam-Column Joint of Elevated Water Tank

Shahayajali Sayyed
Department of Civil Engineering
G H Raisoni University

Abstract*-In this Paper the study is carried out on reinforced cement concrete intze and circular flat base water tank which are commonly used in practice. In order to compare the seismic response of various models have been modeled using ETAB 2016 and STAAD- PRO software. For each cases response spectrum method has been discussed. Grade of concrete and steel used are M25 and Fe500.In the analysis special moment resisting frame (SMRF) are considered.*

Keywords:Beam, column, Intze Water Tank, Circular Water Tank, Seismic force, Staging.

I. INTRODUCTION

Elevated tank structures are normally used to store water for domestic activities and also firefighting purposes. Their safety performance is a critical concern during strong earthquakes. The failure of these structures may cause serious hazards for citizens due to the shortage of water or difficulty in putting out fires during earthquakes. Some elevated tanks have shown insufficient seismic resistance in past earthquakes which had prevented the firefighting process and other emergency response efforts (Barton and Parker, 1987). There have been several studies in which the dynamic behavior of liquid storage tanks have been analyzed, however most of them have focused on ground level cylindrical tanks, and very few of them have concentrated upon behavior of elevated tanks. They are heavy structures which a greater portion of their weight is concentrated at an elevation much about the base. Critical parts of the system are columns and braces through which the loads are transmitted to the foundation. Due to the high sensitivity of elevated water tanks to earthquake characteristics such as frequency contents, peak ground acceleration and effective duration of the earthquake records, it seems necessary to ponder the earthquake loading as a non-stationary random pattern.

II. OBJECTIVE OF STUDY

The scope of present research work is limited to following structural considerations:

1. Elevated water tank is analyses foe capacity of 9 lack litre.
2. The analysis is carried out using ETAB 2016 and STAAD-Pro. Software.
3. Seismic analysis is carried out for intze and circular flat base water tank.
4. Analysis of Beam- column Joint by IS 456-2010.
5. Comparison of design parameters.

III. LITERATURE SURVEY

Large number of papers has been published till date related to seismic response of elevated water tanks. Researchers used different types of model and analytical and experimental techniques to find out the seismic response of these structures. Such studies are being used to provide guidelines and appropriate methods to ensure safety of elevated water tanks as far as possible in the event of earthquake.

In ACI web sessions 1976, when the structure detailed in Figure was being tested for checking the type of joint failure an unexpected result obtained and the beam failed instead of the failure at joint. While investigating this issue the column to beam moment capacity ratio obtained was more than one.

Hence this concept of moment capacity ratio came into picture. Column–beam flexural strength ratio is certainly an important variable for consideration in overall frame performance. It also determines whether it is the capacity of beam or column that will establish the input force for which joint is designed.

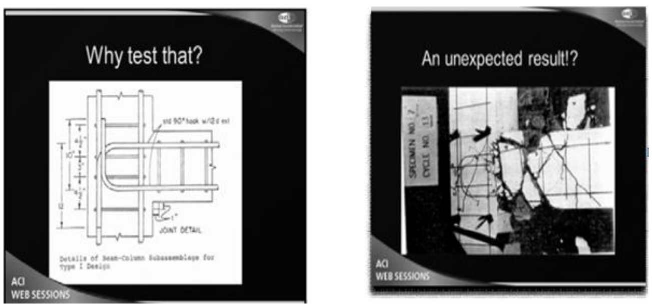

Fig. Testing details of joint in ACI web sessions 1976

Many international design codes recommend that design flexural capacity of columns framing into the joint is greater than design flexural capacity of beam framing into it. According to some of these codes this ratio varies from 1 to 2. But failure of numerous code compliant buildings during past earthquake by formation of storey mechanism raises concern on the requirements. There are many discrepancies among these codes. Hence current code provisions are inadequate to prevent column hinges. Also IS codes are silent on this aspect. This is the underlying motivation for the present study.

III. METHODOLOGY

In this paper the study is carried out on reinforced cement concrete intze and circular flat base water tank which are commonly used in practice. In order to compare the seismic response of various models have been modeled using ETAB 2016 and STAAD- PRO software. For each cases response spectrum method has been discussed. Grade of concrete and steel used are M25 and Fe500.In the analysis special moment resisting frame (SMRF) are considered. Elevated water tanks having 900000 liter capacity with staging heights of 3 m@ 5Nos., 4m@5Nos &5m@5Nos of each panel are considered for study. Complete analysis is carried out for dead load, tank full , tank empty condition & seismic load. All combinations are Considered as per IS 1893:2002-II.

Beam column joints in a reinforced concrete moment resisting frame are crucial zones for transfer of loads effectively between the connecting elements (i.e., beams and columns) in the structure and hence shear strength checked and design by IS 456-2010.

Geometry and Modeling:-

Model 1. Flat based elevated water tank of capacity 900cum .with staging height of 3m each of 5No's in seismic zone III.
Model 2. Flat based elevated water tank of capacity 900cum .with staging height of 4m each of 5No's in seismic zone III.
Model 3. Flat based elevated water tank of capacity 900cum .with staging height of 5m each of 5No's in seismic zone III.
Model 4. Intze type elevated water tank of capacity 900cum .with staging height of 3m each of 5No's in seismic zone III.
Model 5. Intze type elevated water tank of capacity 900cum .with staging height of 4m each of 5No's in seismic zone III.
Model 6. Intze type elevated water tank of capacity 900cum .with staging height of 5m each of 5No's in seismic zone III.

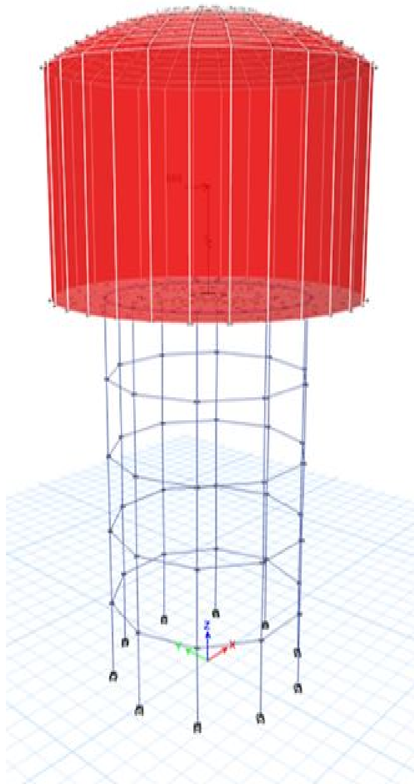

Fig.1: circular flat based Tank.

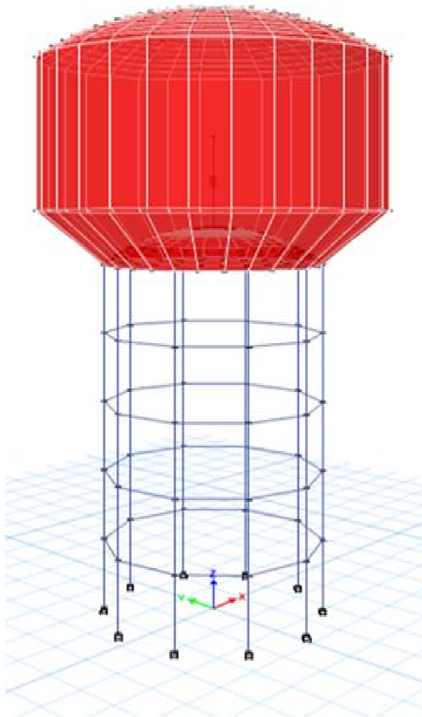

Fig.2: circular Intze type Tank .

Abstract of Container Design: Circular ESR

Code Referred		IS 3370 -1965,67,2009LSM		
Water Tank type :		Circular ESR		
	Capacity =	900	Cum	
Materials used				
	concrete =	M25		
	Steel =	fe 500		
	Dimensional Details:			
	H/D ratio for container=	0.65		
	Height of Tank including free board =	8	M	
	Diameter of tank =	12	M	
Sr.No	Container Details	At Base		
1	Thickness of wall required (mm)	142.1124	Mm	
2	Thickness of wall provided . (mm)	300	Mm	
3	Hoop tension (kN)	532.44		
4	Bending moment (kN-m)	69.6576		
5	Shear Force (kN)	130.08		
6	Horizontal Reinf (Hoop) required.(mm2)	1474.699		
7	Vertical Reinf (BM) required.(mm2)	924.0043		
8	minimum Reinforcement (mm2)	600		
9	Roof Dome Details			
	Rise of Dome =	2	M	
	Thickness of dome =	100	Mm	
	Ast required =	240	mm2	
10	Dome Ring beam Details:			
	Size			
	Width =	350	Mm	
	Depth =	350	Mm	
	Reinforcement =	452.3904	mm2	
11	Floor Slab Details			
	Thickness =	210.1895	Mm	
	Thickness provided =	300	Mm	
	Main steel			
	At center of slab (sagging) =	6498.043	mm2	
	At edge of slab (Hogging)=	1070.118	mm2	

Abstract of Container Design: Intze ESR

Code Referred		IS 3370 -1965,67,2009 LSM		
Water Tank type :		INTZE ESR		
	Capacity =	900	Cum	
Materials used				
	concrete =	M25		
	Steel =	fe500		
I	Container Dimensional Details:			
	H/D ratio for container=	0.65		
	Height of Tank including free board =	8	M	
	Diameter of tank =	12	M	
Sr,No	Container Details	At Base		
1	Thickness of wall required (mm)	99.1906		
2	Thickness of wall provided . (mm)	260	M	
3	Hoop tension (kN)	385.1513	Mm	
4	Bending moment (kN-m)	40.72177	mm2	
5	Shear Force (kN)	89.56437		
6	Horizontal Reinf (Hoop) required.(mm2)	2962.702		
7	Vertical Reinf (BM) required.(mm2)	650.997		
8	minimum Reinforcement (mm2)	624	Mm	
9	Roof Dome Details		mm2	
9	Rise of Dome =	2.2		
10	Thickness of dome =	100		
	Ast required =	240		
11	Dome Ring beam Details:		Mm	
	Size		Kn	
	Width =	300	mm2	
	Depth =	300	mm c/c	
	Ast required =	574.2996		
12	Wall Ring beam Details:		Mm	
	Size		mm2	
	Width =	500	mm2	
	Depth =	1800	mm2	
	Hoop tension =	1910.5		
	Hoop Reinforcement =	5754.519		
	shearreinf. 8mm dia 2legged at	125.664	M	
13	Bottom conical Dome Details		mm2	
	Thickness of dome =	450		
	Ast Hoop required =	5754.519		
	Ast for Bending moment =	387.4508		
	Ast min =	1080		
14	Bottom spherical Dome Details			
	Rise of Dome =	1.4399		
	Thickness of dome =	350		
	Ast required =	840		

Optimized dimensions of Frame

Type	3m staging	4m staging	5m staging
Flat based			
column (mm)	500	600	650
Braces (mm)			
Depth	450	450	450
Width	450	450	450
Intze Type			
column(mm)	500	550	600
Depth	450	450	450
Width	450	450	450

Load calculations

Dead loads : Due to self weight of Structure as per IS875.
Roof live : 1.5KN/Sqm as per IS875-II
Water loads : weight of water in the container.
Seismic Loads : As per IS 1893-2016-II. Sloshing effect not considered.

IV. CONCLUSIONS

From the above study done, the following conclusions are observed:

1. Base reactions are more in intze type tank as compared to flat based tank.
2. Max joint Displacements are also more in earthquake force directions In Intze type tank.
3. Max joint reactions are less in flat based tank as compared to intze type.
4. The axial force in column is steady in flat based tank but its more in intze type.
5. The shear in column decreases with staging height, values are less in flat based tanks than intze.
6. Column design moments increases with increase in staging height.
7. Design forces in braces are less in tank with 4m staging height column.
8. Design steel in bracings is found less in flat based 4m staging tank.
9. Shear reinforcement is nearly uniform in all types of staging but has less in flat based as compared to intze type.
10. B/C joint ratio is found to be near optimized value in inze type tank.
11. Joint stresses in intze type are found to be more in all cases as compared to flat based tank.

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