Analysis of A Surge Tank Considering Hydraulic Pressure Under Lateral Loading Conditions Using Staad.Pro

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Abstract- *Water hammer is a phenomenon that happens in closed conduits when the water velocity and flow changes because of the sudden closed. This phenomenon can cause the bursting of pipe by the very high fluidal pressure. The cases of bursting pipe often happen on the long dimensional pipes such as penstock that distributes water from reservoir to the power house in hydroelectric power plants system. To reduce the water hammer effect in the penstock, surge tank is used as an energy reducer. Surge tank would be used as a physical model to simulate hydraulic condition.*

The observation comprises of water level and mass oscillation in surge tank after the valve is closed rapidly. Fluctuation of mass oscillation in surge tank is temporary until the water level reaches its steady state level. Surge tanks have important role in the functionality of HE plant as they balance the pressure variation in cases of sudden rise or decrease. They are a massive construction that can receive the water in several cases. The cost of these tanks varies according to several factors such as dimensions, construction and maintaining works and shape.

This study deals with the performance of surge tank considering seismic and wind forces with two different conditions namely with pressure and without pressure.

This research provided and explanatory description regarding the process of surge tank considering water pressure further discussing types of surge tanks and their functionalities. The parameters of the research was to utilize and analyze staad.pro for analysis of surge tank as per Indian coral provision, determine the variation in forces, moment and displacement in two conditions namely empty and with pressure of surge tank and further determine the effect of lateral forces i.e seismic forces according to 1893 part I 2016 and wind effect on different directions over surge tank..

Keywords- Hydro-electric power plant, mass oscillation, steady state flow, surge tank, water hammer

I. INTRODUCTION

Water hammer is an impact delivered by the end of the valves at hydro-force plants. This impact can be imply to as a forceful weight change because of the change of Kinetic energy into pressure energy. During this cycle, there is rotating pressure in the pipeline that associates the channel of the repository with the turbines. In models, the forced stream is worked by the headrace burrow (normally concrete-lined) and the weight shaft (for the most part steel lined). Furthermore, a Surge tank is put at the progress from headrace to pressure shaft if the weight burrow arrives at a specific length. This is expected to control the weight of the water and ensure the channel framework, just as permit sensible reaction time to permit the guideline capacity of machine activity.

The Expression Surge tank in German: "Wasserschloss", originates from the Latin expression "castellum" from when the Romans utilized it as a name for transfer device for the water gracefully framework. In Hydro-force plants, it is utilized to restrict pressure swings and to permit guidelines. It mirrors the weight waves that are made by the water hammer marvel. So this occurs because of increasing speeds of water that show up at the pressure shaft created from the end of the valves at Hydro-force plants.

Fig 1: Surge Tank

Functions of Surge Tank

- Provide a free supply surface near the release guideline instrument. This will stop and breaking point the conductor length restrained to water hammer pressure.
- Supplies the extra water required by the turbine during load request & stores water during load dismissal until the conductor speed has quickened, deaccelerated to the new consistent state esteem.
- Ensures the pendulation of water levels following load changes of little just as huge greatness is extinguished decidedly and quickly.
- It ought to Protect the conductor framework from high inside weights.
- It should help the water driven turbine concerning its guideline attributes.
- It should store the water to bring the weight up in pressure drop conditions.

Objectives of the Study

- To perform Finite element analysis of a RCC surge tank using staad.pro software
- To determine the variation in forces, moment and displacement in two conditions namely Under pressure or without pressure.
- To determine the effect of lateral forces i.e seismic forces according to 1893 part I 2016 and wind effect over surge tank.
- To determine the performance of RCC surge tank under pressure.

II. LITERATURE SURVEY

Jiandong Yang et. al. (2016) The investigation paper intended to receive a 1D mathematical reenactment technique to set up a numerical model of a surge tank ventilation tunnel" framework and to determine a breeze speed recreation strategy. From there on, from the viewpoint of wave superposition, the successful system of water-level variations in a flood tank, and the state of the ventilation burrow for forwarding circulation and the breeze speed change measures are found.

The end got from the exploration paper expressed that the proposed one-dimensional reenactment technique could be utilized to precisely mimic the breeze speed in the ventilation passage of a flood tank during transient cycles. The variance in wind speed can be superimposed by utilizing the low-recurrence principal waves just as the high-recurrence consonant waves. The crucial waves can be inferred by utilizing the water-level vacillation in a flood tank. The basic wave relates to the mass wave; its period was equivalent to the time of the water-level vacillation in a flood tank and its abundancy was impacted by the water-level variance speed and the mass stream in the ventilation burrow. The consonant wave relates to the flexibility wave; its period (4L/B) was corresponding to the length and its plentifulness was relative to the gas inactivity in the ventilation burrow. The abundancy of a symphonious wave increment slowly from the primary segment (i.e., the main segment is zero) to the last area along the pivot and bit by bit diminishes after some time. The water-level variance in a flood tank and the sectional territory of the ventilation burrow extraordinarily influence the abundancy of the key and symphonious waves. The time of a major wave can be dictated by utilizing the water-level vacillation. The ventilation burrow length can be utilized to extraordinarily influence the period and plentifulness of symphonious waves, while the plunge point impacts the consonant wave abundancy.

GhulamNabi et al (2011) the investigation paper introduced the water-forceed structure of flood tanks for the two possible destinations in Pakistan that were broke down for flood wave stature and time to disperse. Flood tanks intended for the GolenGolhydroforce task and Satparahydroforce venture were investigated for the water-forceed transient under the two operational situations for example complete conclusion and complete opening.

Results expressed that for the GolenGolhydroforce plant the best surge tank framework was two chambers when contrasted with a surge tank with a separate chamber and without a chamber. The components of the two-chamber surge tank were the distance across the flooded shaft as 9.0 m and the height of the surge shaft was 100.0 m. This framework gave a base collected flood of 17.5 m. For the Satparahydroforce plant, a surge tank with a lower chamber gave better outcomes i.e aggregated least surge was 3.37 m, when contrasted with a flood tank having two chambers and without a chamber. The components of the flood tank with the lower chamber are the distance across the flooded shaft was.5.66 m and the stature of the surge shaft was 33.0 m.

Henceforth results inferred that for the Satparahydroforce plant, a surge tank without a chamber and surge tank with two chambers delivers a high scope of surges to cause unfortunately substantial lead representative development. While the surge tank with a lower chamber creates the base flood stature when contrasted with different sorts, so the pressure-driven conduct of the surge tank with the lower chamber is more steady than different kinds of surge tanks. So also for Golen Golhydroforce plant surge tank with two chambers delivers better flood security when contrasted with a surge tank with a secluded chamber and no chamber.

III. METHODOLOGY

Following steps are followed as shown below:

Step-1: To prepare a literature survey related to our study.

Literature Survey was ready for the past examination embraced to date and weaknesses were recognized on which further exploration should be executed. This above and beyond managed to introduce the use of Surge Tank in Hydro Force Plants and its possibilities of general applications in different industries.

Step-2:To Prepare geometrical structure of the study using analysis tool STAAD.

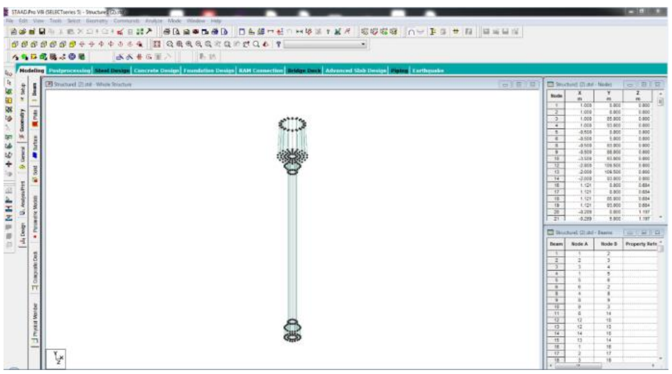


Fig 2: Modelling of Surge Tank using Staad.Pro.

Step-3: To create material properties and assigning at structure.

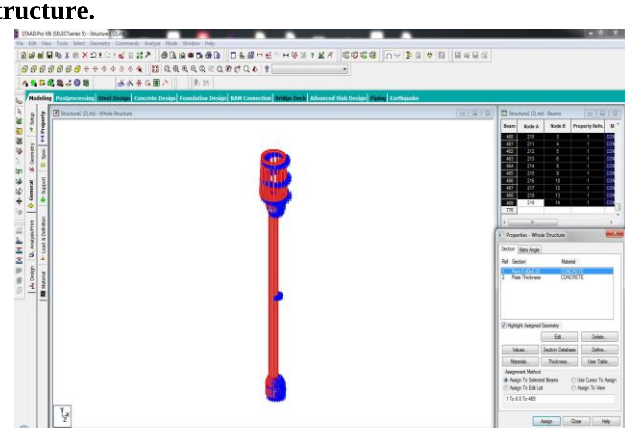


Fig 3: Assigning material and section properties

Step-4: The support is fixed at bottom, pinned at top and weak spring at soil fill area

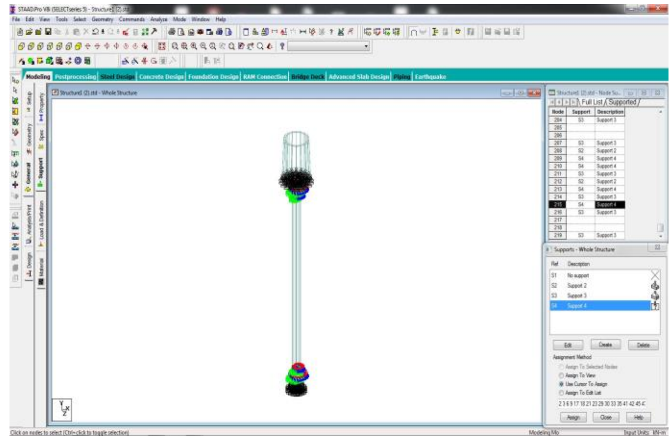


Fig 4: Assigning Support condition

The support is fixed at bottom, pinned at top and weak spring at soil fill area

Step-5: Assigning loading conditions:

Case I Surge Tank with no pressure condition

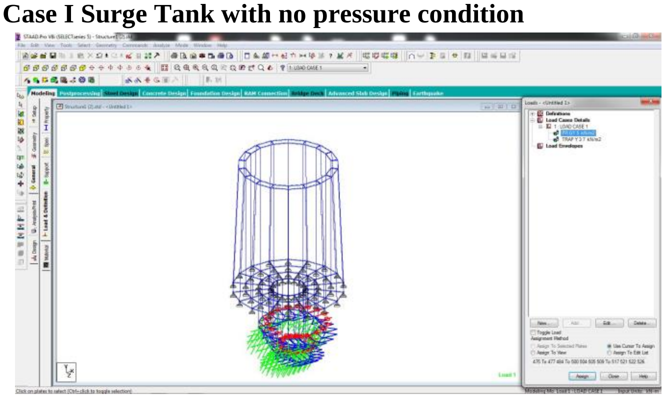


Fig 5: No pressure condition

Case II Surge Tank with pressure condition

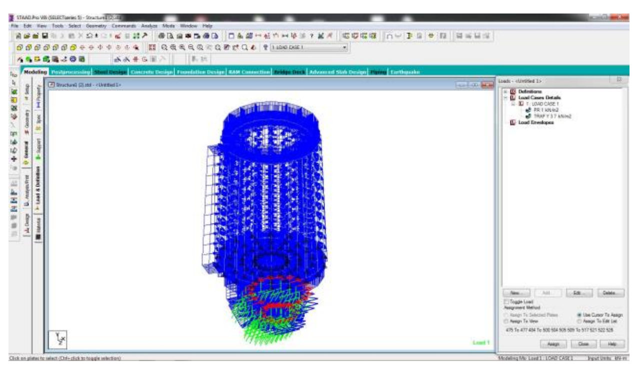


Fig 6: Pressure condition

Step-6: Assigning Backfill Soil Conditions assigned in model

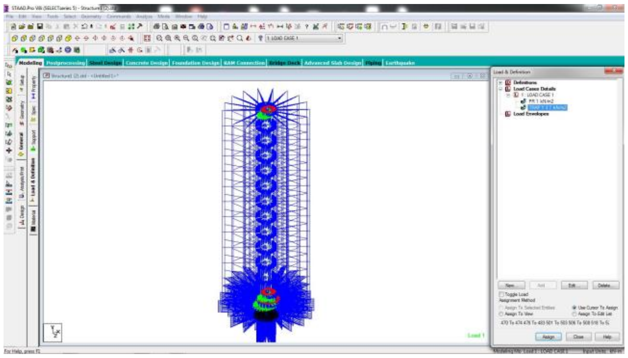


Fig 7: Soil condition assigned to model

Step-7: Stress Analysis of Surge Tank

In this study we are performing finite element study using analysis tool staad and observed that variation is observed at both the considered cases of surge tank.

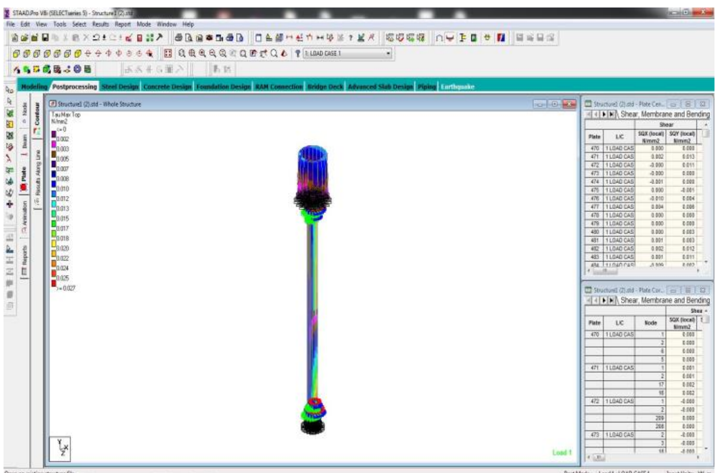


Fig 8: Stress Analysis

Step 8- Analysis Output

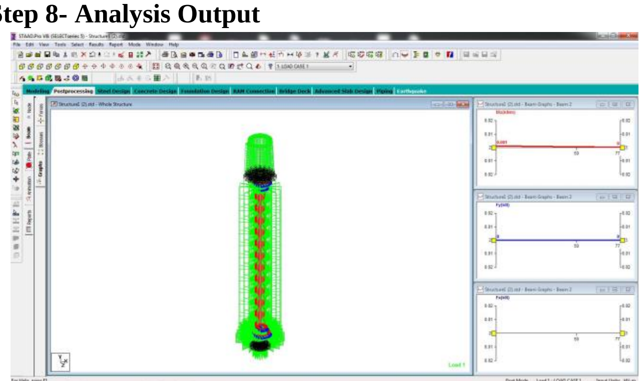


Fig 9: Analysis results

Step-9: Generating report of each case in M.S. excel for comparison.

Problem Formulation

For the examination of the structure, all the load conditions to the structure are applied. The estimations of configuration loads are determined according to IS 875 Part I and II wind load as per 875-III and seismic as per 1893 part I 2016.

Dead loads will be determined based on unit loads of materials given in IS 875 (Part I) which will be built up thinking about the materials indicated for development. The appropriation of dead load, Imposed load is characterized as the load that is applied to the structure that isn't changeless and can be variable.

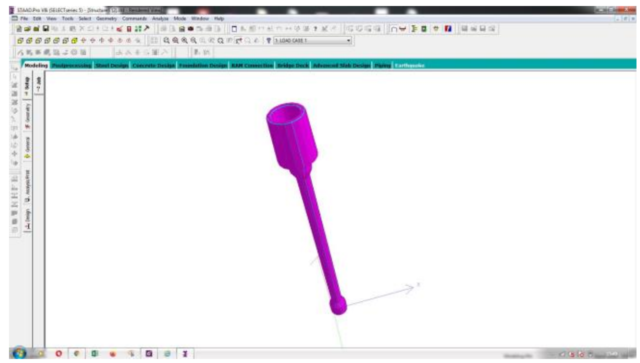


fig 10 3-dimensional structure

Table 1 Plan Dimension of the structure

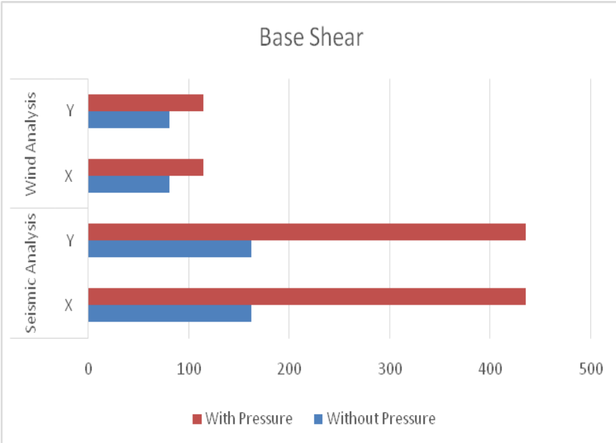
Plan Dimension	
Grade of concrete	M 30
Grade of steel concrete	fe500
Capacity of Tank	1000 KL
Diameter of Tank	14.8 m
Thickness of cylindrical surface	300 mm
Density of Brick (lining)	20 kN/m³
Horizontal members	0.3 x 0.3 m
Vertical members	0.5 m
Height	13 m

Table 2 Sectional Properties

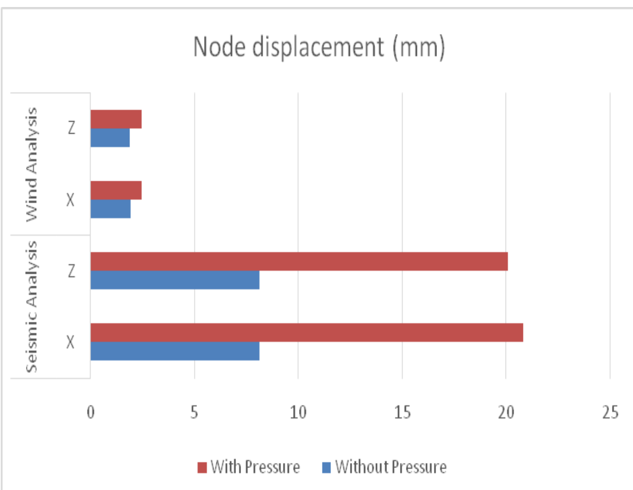
SR.NO.	PARAMETER	DESCRIPTION
1	CONCRETE	M35
2	REBAR	FE 500
3	Modulus of Elasticity	1.95xE5 MPa
4	Ultimate Tensile Strength	1860 MPa
5	BRICK LINING	CLAY BRICK

Analysis Result:

Base Shear:



Node Displacement:



Overturning Moment:

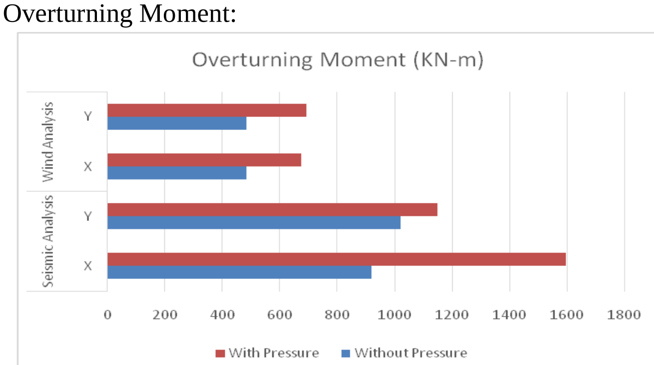


Table 3: Stresses induced in circular plates

Node	Without Pressure			With Pressure			Ratio		
	Ux_1 mm	Ry_1 rad	Rz_1 rad	Ux_2 mm	Ry_2 rad	Rz_2 rad	Ux_2/Ux_1	Ry_2/Ry_1	Rz_2/Rz_1
26	39.59	0.001	-0.001	31.21	0	-0.001	0.79	0	1
27	39.58	0.001	-0.001	31.21	0	-0.001	0.79	0	1
56	44.32	0	-0.002	30.32	0	-0.001	0.68	**	0.5
57	44.3	0	-0.001	30.32	0	-0.001	0.68	**	1
86	43.32	-0.001	-0.002	29.41	0	-0.001	0.68	0	0.5
87	43.3	-0.001	-0.001	29.42	0	-0.001	0.68	0	1
116	36.14	-0.001	-0.001	28.52	0	-0.001	0.79	0	1
117	36.08	-0.001	-0.001	28.5	0	0	0.79	0	0
118	36.01	0	-0.001	28.46	0	0	0.79	**	0
119	35.97	0	-0.001	28.44	0	0	0.79	**	0
120	35.95	0	-0.001	28.44	0	-0.001	0.79	**	1
146	33.07	0	-0.001	27.65	0	-0.001	0.84	**	1
147	33.05	0	-0.001	27.65	0	0	0.84	**	0
148	33.02	0	-0.001	27.66	0	0	0.84	**	0
149	33.01	0	-0.001	27.67	0	0	0.84	**	0
150	33	0	-0.001	27.67	0	-0.001	0.84	**	1

IV. CONCLUSION

- Base shear forces due to wind gave the maximum value to 80.47kN in X and Y axis considering without pressure condition whereas with pressure conditions increases these values to 114.16kN in both the X and Y direction.

Base shear forces due to seismic loads provided the maximum values in empty condition as 162 kN in both the X and Y direction whereas the values raised to 435 kN in case of with pressure condition in both the direction.

- Maximum Displacement value for wind analysis was found to be 1.87 kN in both the X and Z direction in the case of without pressure situation and the values raised to 2.46 kN in both the directions in case of the counterpart.

Maximum Displacement due to seismic load was found to be 8.134 kN in X direction and a major impact was seen in the with pressure case as 20.79 kN in X direction and 2.079 kN in Z direction.

- Seismic impact was visible on the overturning moment of the structure in both X and Y axis.
- This project critically reviews earthquake induced forces on container systems and it is observed that there is a maximum increase of 15% to 25% in hydrodynamic pressures in surge tank, respectively.

V. FUTURE SCOPE

Following future scopes can be consider as:

- In future one can consider different height of surge tanks for variations in release in pressure.
- In future one can consider manual and software outputs for comparison.
- In this study we have considered lateral loads i.e. wind and seismic both whereas in future one can select different analysis method with different regions.
- In this study we performed analysis whereas in future one can also design and prepare cost analysis of the same.

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