Design, Analysis and Comparison of Underground Rectangular water tank by using STAAD Provi8 software

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***Abstract* - A water tank is a container for storing water. The need for a water tank is as old civilization, to provide storage of water for use in many applications, drinking water, irrigation agricultural, fire suppression, agricultural farming, chemical manufacturing as well as many other uses. An Underground water storage tanks (or sub-surface tanks) are used for underground storage of potable drinking water, wastewater & rainwater collection. And it is a water storage structure constructed below the ground. The term also includes structures that are partially below ground. The paper includes the study of UG Rectangular tank that how the shape deflected and what are the actions will be produced when tank empty or full by using STAAD Pro software that discussed.**

***Index Term* - UG tank, design, analysis, STAAD Pro software, criteria, damage, actions, dead load, BM.**

I. INTRODUCTION

In recent years, there has been much emphasis on water supply projects all over the world, which are very essential for the social and industrial development of the country. Water tanks can be of different capacity depending upon the requirement of consumption. Based on the location the water tanks are classified into three ways:

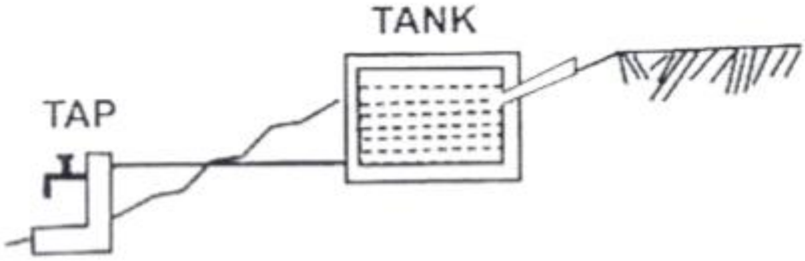
1. Underground water tanks
2. Tank resting on grounds
3. Elevated or overhead water tanks.

Also, the water tanks are classified based on shape:

1. Circular tanks
2. Rectangular tanks
3. Intz tanks
4. Circular tank with conical bottom
5. Spherical tanks.

As we know, UG tank is used for storing water below the ground level. In most cases, underground tanks collect and store runoff from ground catchments such as open grasslands, hillsides, home compounds, roads, footpaths, paved and unpaved areas. However, in certain circumstances, roof catchments can also be channelled into underground tanks.

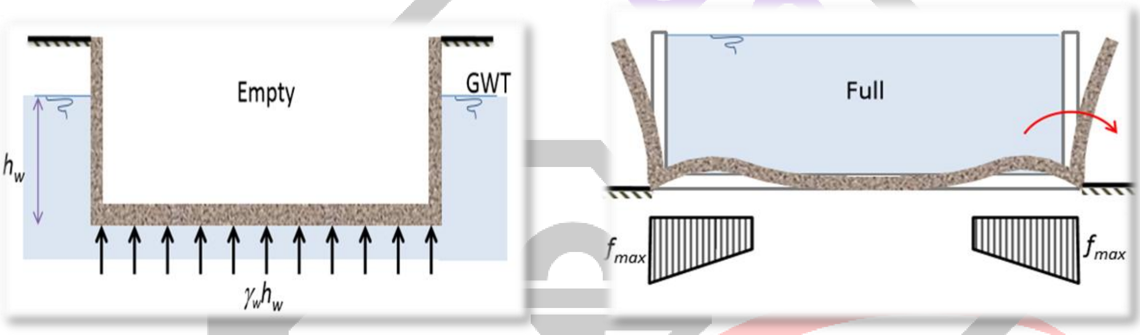
- The UG water tank has three basic components; i.e., top slab, sidewalls and base slab.
- Also Underground storage is most advantageous when large volumes are to be stored. Underground storage is especially advantageous for high vapour pressure products.
- **An UG tank is classified as under:**
  - a) UG tank as per range:
    - a) Wide underground water tanks (e.g. Swimming Pools)
    - b) Short underground water tanks
  - b) As per use of materials the tank is typed in three ways:
    - a) Steel/aluminium tank, made by manufacturers in most states and conforming to standards set by the Steel Tank Institute.
    - b) Composite overwrapped a metal tank (aluminium/steel) with filament windings like glass fibre/aramid or carbon fibre or a plastic compound around the metal cylinder for corrosion protection and to form an interstitial space.
    - c) Tanks made from composite material, fiberglass/aramid or carbon fibre with a metal liner (aluminium or steel).
- **Features of underground tank:**
  - a) Rectangular shape makes best use of available space
  - b) May be installed at or below ground level or on towers
  - c) Clear interior allows easy inspection, draining and painting.



Sketch of an underground water tank arrangement (in general).

II. DESIGN STEPS FOR UG RECTANGULAR WATER TANK

- **Design steps are involving:**
  1. Stability
     a. Uplift Check
     b. Check of Stresses on Soil
  2. Strength
     a. Design of Critical Sections.



Sketches Show the results when tank empty as well full.

III. PRIMARY DATA OF UNDERGROUND RECTANGULAR WATER TANK

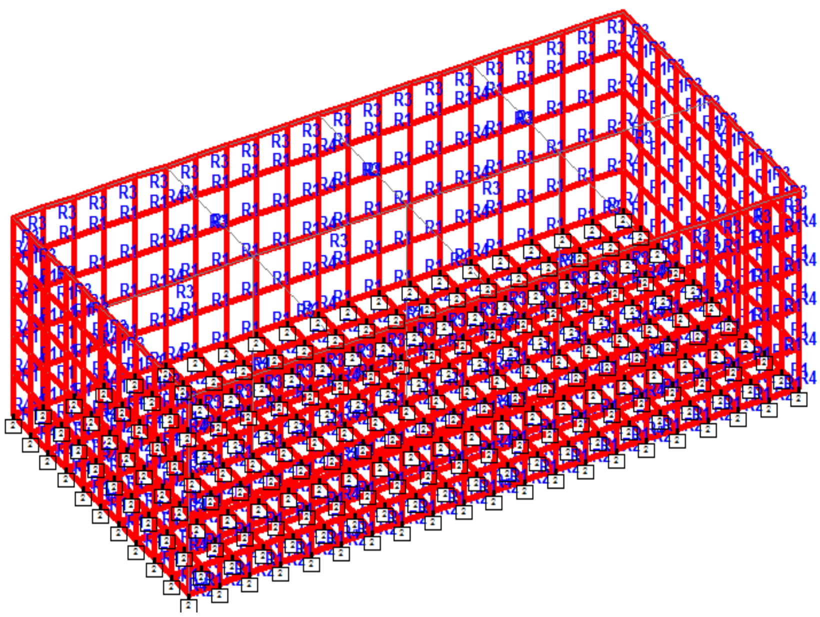
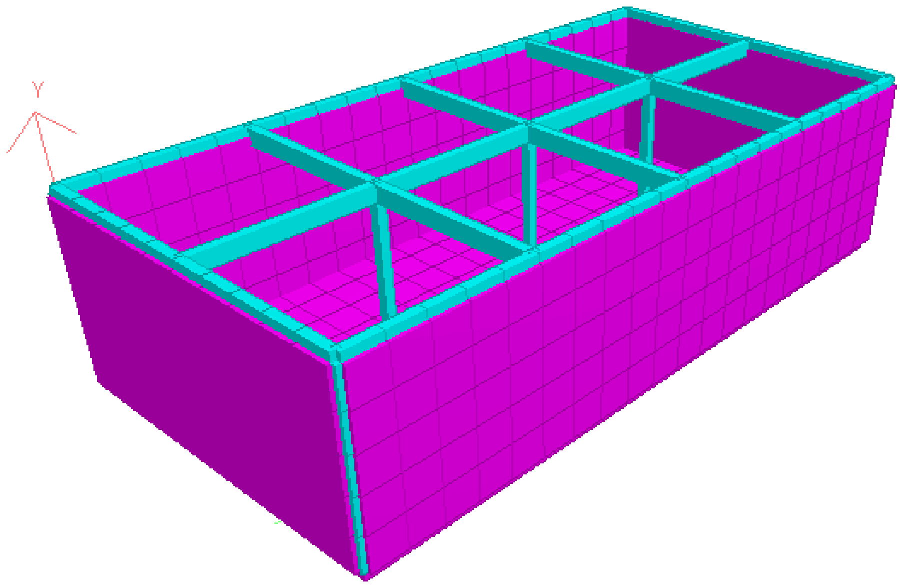


Figure shows the primary data in STAAD Pro design for Rec. Water tank



3d view of the rectangular tank

IV. SUMMARIZATION OF PRIMARY DATA

1. User defined material data like span, load and grade of concrete and steel are to be given as input.
2. Maximum bending moment and shear force has to be calculated.
3. The deflected shape is analysed and also the axial force of respected tank cases.
4. We have taken two cases with different data as input:
   - The size of water tank is 20mm x 10mm x 5.5mm.

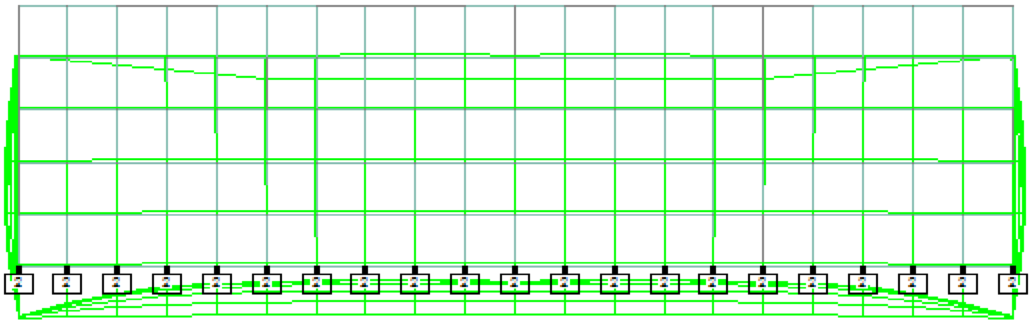
a) Case: 1.The below data is taken to design the underground tank:

- Beam section: 500mm x 250mm
- Column section: 250mm x 250mm
- Wall thickness: 450mm
- Floor thickness: 750mm
- Cover thickness:300 mm

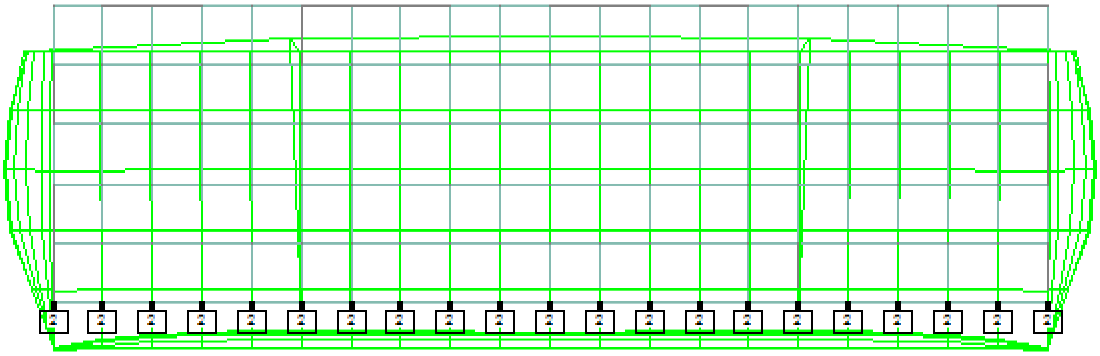
b) Case: 1.The below data is taken to design the underground tank:

- Beam section: 500mm x 250mm
- Column section: 250mm x 250mm
- Wall thickness: 200mm
- Floor thickness: 400mm
- Cover thickness:300 mm

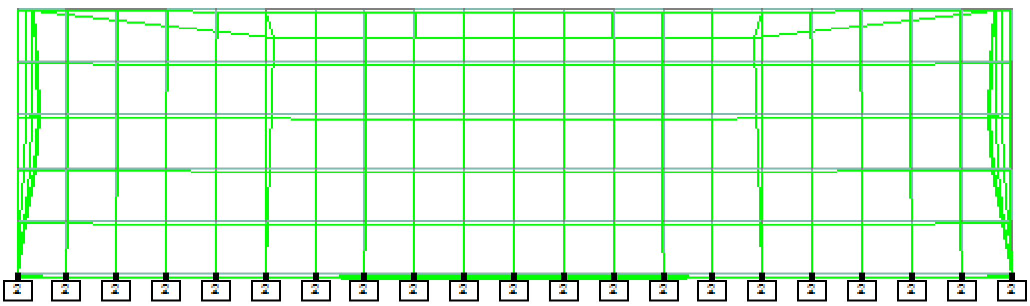
V. CALCULATION AND DESIGN RESULTS FROM THE SOFTWARE ARE:



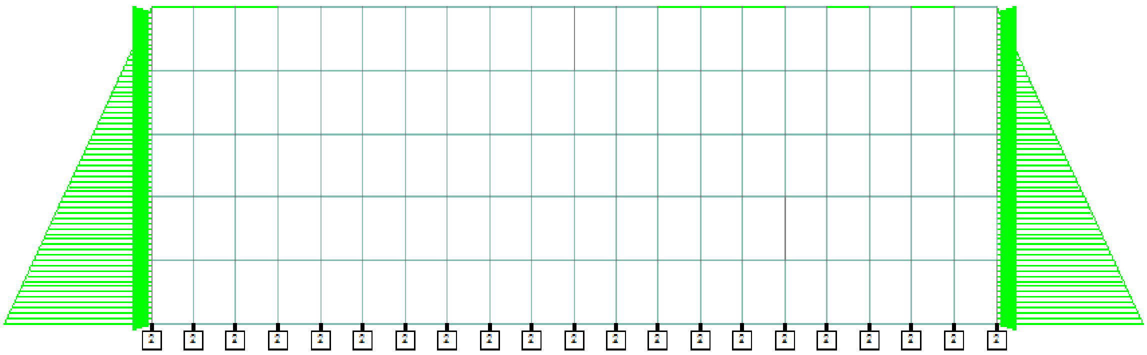
FRONT VIEW: DISPLACEMENT DUE TO DEAD LOAD



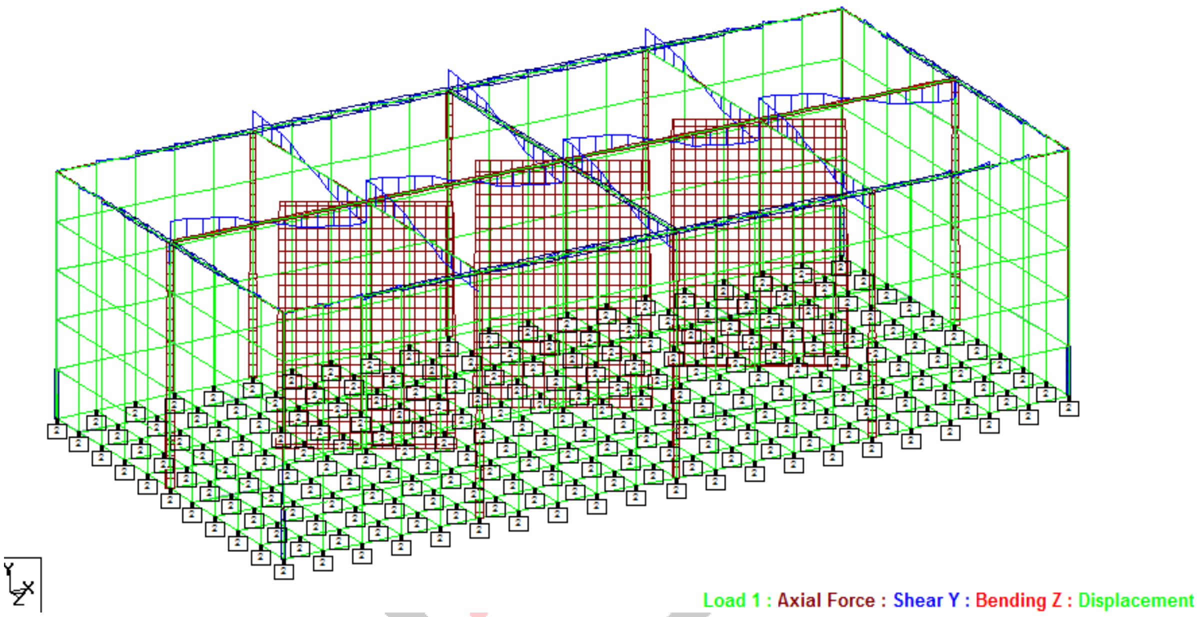
FRONT VIEW: DISPLACEMENT OCCUR WHEN WATER IN TANK



FRONT VIEW: DISPLACEMENT OF EXTERNAL SOIL PRESSURE TO TANK



SOIL PRESSURE AROUND THE TANK



Deflected shape of the tank due to BM, AF and Shear

VI. FINAL RESULT OF BOTH THE CASES (RESPECTIVELY) OF UG RECTANGULAR WATER TANK

TABLE NO – 1. Comparing the both cases from the result by software

ug1 - Node Displacements: (All / Summary)

	Node	L/C	Horizontal X in	Vertical Y in	Horizontal Z in	Resultant in
Max X	340	5 TANK FULL	0.043	-0.063	0.000	0.076
Min X	266	5 TANK FULL	-0.043	-0.063	0.000	0.076
Max Y	7	4 UPLIFT	0.000	0.005	0.000	0.005
Min Y	19	6 SOIL PRES	-0.006	-0.071	0.000	0.071
Max Z	101	5 TANK FULL	0.000	-0.062	0.055	0.083
Min Z	193	5 TANK FULL	0.000	-0.062	-0.055	0.083
Max rX	10	5 TANK FULL	-0.000	-0.063	-0.014	0.064
Min rX	13	5 TANK FULL	0.000	-0.063	0.014	0.064
Max rY	281	5 TANK FULL	-0.023	-0.063	0.001	0.067
Min rY	351	5 TANK FULL	0.023	-0.063	0.001	0.067
Max rZ	16	5 TANK FULL	0.017	-0.064	0.000	0.066
Min rZ	15	5 TANK FULL	-0.017	-0.064	0.000	0.066
Max Rs	101	5 TANK FULL	0.000	-0.062	0.055	0.083

ug2 - Node Displacements: (All / Summary)

	Node	L/C	Horizontal X in	Vertical Y in	Horizontal Z in	Resultant in
Max X	340	5 TANK FULL	0.243	-0.066	0.000	0.252
Min X	266	5 TANK FULL	-0.243	-0.066	0.000	0.252
Max Y	7	4 UPLIFT	0.000	0.005	0.000	0.005
Min Y	17	5 TANK FULL	-0.012	-0.092	0.000	0.093
Max Z	101	5 TANK FULL	0.000	-0.067	0.304	0.311
Min Z	193	5 TANK FULL	0.000	-0.067	-0.304	0.311
Max rX	111	5 TANK FULL	0.000	-0.066	0.130	0.146
Min rX	195	5 TANK FULL	0.000	-0.066	-0.130	0.146
Max rY	317	5 TANK FULL	0.056	-0.067	-0.002	0.087
Min rY	293	5 TANK FULL	-0.056	-0.067	-0.002	0.087
Max rZ	270	5 TANK FULL	-0.112	-0.065	0.000	0.130
Min rZ	342	5 TANK FULL	0.112	-0.065	0.000	0.130
Max Rs	101	5 TANK FULL	0.000	-0.067	0.304	0.311

VII. CONCLUSION

1. Plastic underground water tanks (cistern) is a great alternative to concrete cisterns.
2. Uplift check (in case of ground water, during maintenance): Must be Dead loads > Uplift loads.
3. Stresses on soil (in case of full tank, just after construction): Must be Stresses on soil < allowable stress.
4. If the criteria are not to be fulfilled (as in point 2 and 3) or if unsafe then,
    a. Increase floor thickness.
    b. Use plain concrete inside tank (above RC floor)
    c. Use plain concrete below RC floor (connected with steel dowels).
    d. Use toe to include soil weight.
    e. Use tension piles.
5. If we are not chooses the proper section of tank, will be fail. As in case 2 with compare to case 1, sections are used (thickness of slab and walls) less dimension which result in fail.

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