Industrial Potable Water Infrastructure Project

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Abstract

This project is for the design of an industrial-grade potable water infrastructure system capable of supporting all required manufacturing activities with approximately 100 employees, for three days after the occurrence of an external city water disruption event. The design will be performed according to the user's requirements and specifications, which is the key to fulfilling the client's needs and robust infrastructure design. The scope will include mechanical distribution, storage capacity, structural and seismic design, external servicing capability, with automation operational control equipment..

Introduction

Water plays a vital role in manufacturing operations, from cooling equipment to creating manufacturing products and people's use. Manufacturing plants, such as factories, food and beverage industries, depend greatly on reliable water use and storage options to ensure smooth functioning and compliance with regulations.

When the water supply chain is disrupted, manufacturing operations result in downtime. Furthermore, water scarcity may cause product contamination, safety breaches, and decreased operational effectiveness. The avoidance of these adverse scenarios can be diminished with the use of potable water storage tanks.

Background

To maintain the continuous supply of potable water during an external disruption event, it is important to have a stored amount of potable water enough to cover an average disruption event duration. When deciding on a water storage option for your manufacturing facility's needs, the choice of a water reservoir tank plays an important role in managing your water resources. Steel bolted water storage tanks are commonly used in industries for their flexibility in size options, from small (1,000 Gallons) to large-scale (6 million Gallons) capacities. Why Choose Steel Core Tanks? Durability, Customization, Compliance, Quality, In-place Installation, and it's a Great value. Steel Core offers cost solutions by providing high-quality products with highly durable tanks requiring little maintenance.

Problem

Industrial manufacturing campuses are typically impacted due to external disruptions of the potable water supply. To reduce the impact of these events, this investigation is aligned to bring a design solution capable of bringing potable water from a storage potable water container (steel-core tank) for three consecutive manufacturing days. Through this analysis, we will be working with the design of a water storage capacity selection, tank structural base-footing design, and a potable water distribution system to ensure the coverage through restoration of a typical external potable water disruption scenario.

Methodology

Using mathematical design methodologies and engineering code requirements, a potable water infrastructure was designed to supply 100% of the required industrial manufacturing demand based on the following criteria:

Daily Per-Capita Demand.
- Light manufacturing Industry: **40–60** gallons per day (GPD) per employee.

Storage Requirements
- On-site storage capacity for at least **48–72 hours** of supply.
- Minimum water distribution pressure of **45–80 psi** for process stability.

Distribution Requirements Pipe Materials:
- Ductile Iron (DI) or High-Density Polyethylene (HDPE) for main supply lines.
- Copper type L piping for internal potable water lines.

Water flow recommended velocity:
- Minimum Velocity: 2 ft/s to prevent stagnation.
- Maximum Velocity: 8 ft/s to prevent piping erosion.

Pumping & Pressure Management
- Variable Frequency Drives (VFDs) on pumps for pressure control and energy use efficiency (DOE, 2021).
- Backflow prevention devices to protect against cross-contamination.
- Inlet water pressure regulation for overpressure control while supplying water from external sources.

To be sourced by the city's potable water system, our potable water infrastructure must with the following:
- A formal potable city water metering service from Puerto Rico Aqueducts and Sewer Authority (PRASA).
- A backflow preventive device connected to the main potable water inlet source to avoid backflow contamination.
- The installation of a water pressure regulator to control the required water pressure throughout the facility.
- The potable water distribution piping must comply with PRASA and Building Codes requirements.

These are the specific industrial manufacturing considerations for the potable water demand analysis:
- The manufacturing building operates with **100** light industrial employees.
- Manufacturing process water consumption of **5** gallons of potable water per minute (GPM) per shift, 2 shifts per day.
- The manufacturing cleaning process uses **1000** gallons of potable water per week.
- Buildings and grounds maintenance uses **500** gallons of potable water per day.
- The cafeteria uses **500** gallons of water per day.

Infrastructure design is evaluated following the American Society of Civil Engineers' (ASCE) hazard considerations report, which provides guidance for safer construction based on soil characteristics, wind exposure, and historical seismic events by location. Our location is Aguadilla, Puerto Rico:
- Wind exposure 174mph
- Risk category III
- Soil class D
- Seismic importance factor of 1.09
- Seismic design category D

Results and Discussion

The industrial manufacturing potable water infrastructure was evaluated and designed, taking into consideration. Below, we are showing an example of some of the design results:

Steel Core Tank Associated Weights
- Full Tank Water Weight: 150,120lbs.
- Empty Tank Weight: 10,484lbs.
- Concrete Footing Weight: 67,515lbs.
- Total estimated maximum load: **228,119lbs**.

Tank-Footing Design Analysis
- Using allowable soil bearing of 4,000psf.
- Rectangular base footing dimensions of 14ft×18ft for a 12ft diameter tank:
- Vertical Load (W): **228,119lbs**
- Lateral Load (H): **8,000lbs**
- Tank height: **24ft**
- Soil Bearing Capacity: **4,000psf**
- Friction coefficient (μ): **0.5**
- Tank Up-lift Force: **6,655lbs**

Bearing Pressure (No Eccentricity) Results
- **905.23psf** (✓ well below 4,000psf of soil bearing capacity).

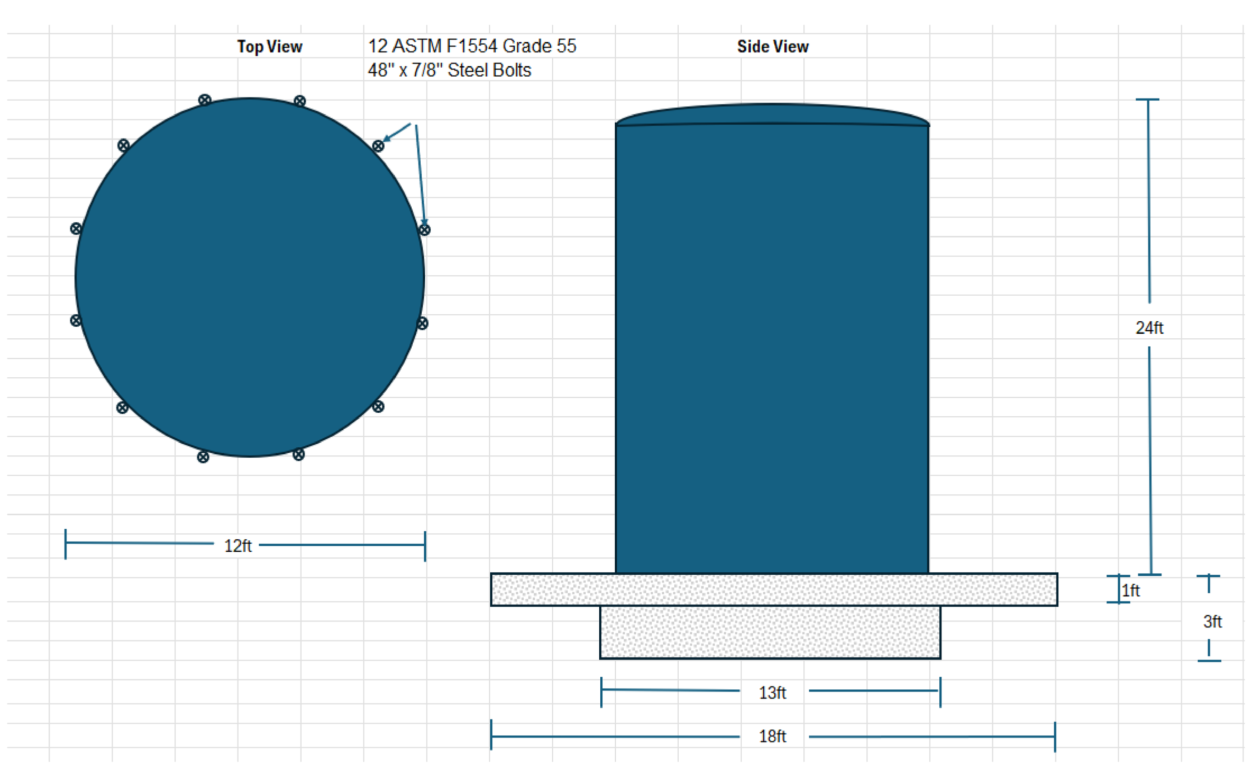
Overturning Resisting Moment Results
- Full Tank Mrf = **1,449,000 ft-lbs**
- Empty Tank Mre = **495,445 ft-lbs**

Overturning Safety Factor Verification
- Full Tank: SF = Mr/Mo =(1,449,000ft-lbs)/(96,000ft-lbs) ≈ **15.09** times (✓ Excellent)
- Empty Tank: SF = Mr/Mo = (495,445ft-lbs)/(96,000ft-lbs) ≈ **5.16** times (✓Excellent)

Max and Min Bearing Pressures:
- $q(max) = (W/A) \times (1+6eL)$ = (638.1psf) x (1+0.1987) = **765.6psf (max)**
- $q(min) = (W/A) \times (1-6eL)$ = (638.1psf) x (1−0.1987) = **510.6psf (min)**

Both are below 4,000psf — footing is in full contact, no tension.

Figure 5
Steel-Core Tank, Anchoring Bolts, and Concrete Footing View



Conclusions

Based results obtained from the evaluation and design of the industrial potable water infrastructure, we conclude the following statements:
- The selection of a steel-core potable water tank is crucial to ensure resilience against weather exposure, hurricane wind, and seismic protection from the potential hazard events at Aguadilla, Puerto Rico, industry location.
- The selection of a 20,000-gallon potable water tank will cover the potable water demand for three consecutive days due to a major potable city water disruption event.
- The selection of the (18ft)x(18ft)x(1ft) concrete base footing meets the required load contact pressure below the actual soil bearing capacity. Additionally, the installation of a circular concrete tank base footing (13ft dia.)x(1ft)x(3ft) for the tank anchoring bolts development length assures a proper interaction between the bolts and the concrete surface. Also, this additional concrete weight increases the moment-restoring effect of the tank. This analysis demonstrates the importance of the tank anchoring implementation to meet hurricane wind resistance, seismic sliding displacements, shear forces resistance, uplift forces resistance, and tank overturning avoidance.

Future Work

The next step for the industrial potable water infrastructure is the upgrading to an automated control system that can switchover itself to the next available potable water source with remote control and parameter monitoring capabilities.

Acknowledgements

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References

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