Typical Prestressed Concrete Tank Foundation Information

A description of DN Tanks’ standard tank foundation consists of a reinforced concrete floor slab with a circumferential shallow spread footing to support the tank wall and tributary roof loads. The tank floor behaves as a membrane such that it is flexible enough to transmit all vertical loadings directly to the subbase. Six (6) to twelve (12) inches of well-compacted crushed stone or granular base material is typically utilized under the tank floor to provide a uniform bearing surface, as confirmed by the geotechnical engineer.

AWWA D-110-13 Section 3.8 Floor design and ACI 372R Appendix A should be considered when the selection of the foundation system is determined.

General information required from the geotechnical engineer concerning the soils investigation for a prestressed concrete liquid storage tank:

1. Recommended foundation system (granular base depth, type, etc.)
2. Ground water elevation at the tank location.
3. Pertinent geotechnical parameter information (see back page)
4. Additional comments and concerns – i.e., expansive materials, flood plain, slope stability problems, influence on other existing structures and utilities, potential for liquefaction, etc.

Borings

A minimum of five borings should be performed. The exact number of borings, depths, and location should be determined by the geotechnical engineer.

A general estimate for the minimum borings required and location is shown below.

Fig. A.2.2a—Recommended boring layout for tank diameters less than or equal to 200 ft (60 m). Note: For tank diameters less than 50 ft (15 m), the number of perimeter borings may be reduced.

Fig. A.2.2b—Recommended boring layout for tank diameters greater than 200 ft (60 m).
Pertinent Information from AWWA D110-13

3.8.2 Membrane floors. In cast-in-place concrete membrane floors, loads are assumed to be transmitted to the subbase directly through the membrane. Floors shall be placed continuously in sections as large as practicable to decrease the length of construction joints and potential leakage problems related to their presence. Precautions shall be taken with large floor sections to limit long-term shrinkage by using concrete with a properly controlled water-cement ratio, adequate reinforcement, and proper curing conditions. Hydrostatic uplift when the tank is empty or when the tank water level is lowered during operation shall be precluded by adequate surface drainage, a perimeter drain around the tank wall foundation, and underdrainage, if necessary.

3.8.4 Subgrade. The subgrade for membrane floors shall have adequate bearing capacity to sustain the weight of the tank, fluid contents, and roof load. The floor slab shall not be constructed directly on the natural subgrade soil or rock unless it is uniform and compact.

3.8.4.1 The subgrade for membrane floors must be of uniform density and compressibility to minimize differential settlement of the floor and footings. Disturbed subgrade or loosely consolidated soil or foundation material shall be removed and replaced with suitable compacted soil, or it shall be compacted in place. Compaction shall achieve a density of at least 95 percent of the maximum laboratory density determined by ASTM D1557. Field tests for the measurement of in-place density shall be in accordance with ASTM D1556. Overexcavation and replacement with compacted imported material may be required if foundation soils are unsatisfactory for the imposed loadings or do not provide uniform support.

3.8.4.2 The subgrade for all types of floors shall be so designed that leakage through the floor will not cause erosion and settlement in excess of that provided for in the design or will not cause other types of failure.

3.8.5 Floor base. Use of clean, well-compacted granular base with a minimum thickness of 6 in. (150 mm) shall be used for tanks when the natural subgrade does not meet the drainage requirements or is difficult to prepare for floor construction. Gradation should be selected to permit free drainage without loss of fines. When suitable base material is not available, the use of geotextile fabrics shall be used.

3.8.5.1 Where site conditions indicate the possibility of hydrostatic uplift of the floor, a properly designed structural floor shall be used or adequate drainage of the floor base shall be provided to relieve the hydrostatic pressure and remove the water from the site. Drainage to a manhole or other drainage structure where the flow can be observed and measured is recommended. The receiving structure shall be below the level of the floor slab to guard against surcharge and backflow to the floor base.
Checklist for Geotechnical Report Content

After the completion of the subsurface investigation, a detailed report should be prepared by an experienced, registered geotechnical engineer. This report should include the following information:

- The scope of the investigation.
- A description of the proposed tank including major dimensions, elevations (including finished floor elevation), and loadings.
- A description of the tank site. This should include a site grading plan, existing structures drainage conditions, type of vegetation on the site, and any other unique features of the site.
- Geological setting of the site.
- Details of the field exploration that was carried out such as number of borings, location of borings, depth of borings, etc.
- A general description of the subsoil conditions as determined from the recovered soil samples, laboratory tests, standard penetration resistance, etc.
- The expected groundwater level at the site during construction and after the project completion.

Geotechnical recommendations, in addition to the parameter list on the next page, including:

- Type of foundation system.
- Subgrade preparation, including limits of excavation (horizontal and vertical); proofrolling and compaction, if necessary (consider the possibility of “pumping” during compaction of the subgrade).
- Foundation base material type and placement procedure, including compaction requirements.
- Tank backfill material type and placement procedure.
- Coefficient of friction between foundation soil base material and concrete, a typical range of coefficient values are 0.5 to 0.6. For tank foundations extended into a rock subgrade, lateral sliding resistance may be obtained by utilizing the shear and compressive resistance of the rock, provide resistance values for this condition.
- If the Geotechnical Engineer provides Net soil bearing capacity, Geotechnical Engineer’s definition of Net soil bearing capacity.
- Factor of safety against sliding to be used, typically value of 1.5 for static and 1.1 for seismic conditions are used.
- Modulus of Subgrade, k (based on a 12in sq. plate)
- Anticipated groundwater control measures needed at the site during and after construction, including the possibility of buoyancy of the empty tank.
- Conclusions and limitations of the investigation.

The report should have the following attachments:

- Site location map.
- A plan indicating the location of the borings with respect to the proposed tank and any existing structures on the site.
- Boring logs.
- Laboratory test results, including Atterberg Limits, unconfined compressive strength, where applicable, etc.
The following geotechnical parameters are requested for the tank design:

<table>
<thead>
<tr>
<th>Backfill Soil Information (If tank is to be backfilled)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Equivalent Liquid At-Rest Pressure (PCF)</td>
</tr>
<tr>
<td>Backfill Pressure Increase on Wall Under Seismic Excitation (PCF)</td>
</tr>
<tr>
<td>Equivalent Liquid Active Earth Pressure (PCF)</td>
</tr>
<tr>
<td>Equivalent Liquid Passive Earth Pressure (PCF)</td>
</tr>
<tr>
<td>Backfill Soil Density (PCF)</td>
</tr>
<tr>
<td>Downward Drag Coefficient of Backfill on Wall</td>
</tr>
<tr>
<td>Vehicle Load on Backfill</td>
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</tbody>
</table>

**NOTE:** Backfill Shall NOT Contain Sulfides or Expansive Material.

<table>
<thead>
<tr>
<th>Soils Information</th>
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</thead>
<tbody>
<tr>
<td>Gross Soil Bearing Capacity, Including Backfill Soil and Liquid Loads (PSF)</td>
</tr>
<tr>
<td>Anticipated Total Settlement of Tank (Inches)</td>
</tr>
<tr>
<td>Anticipated Differential Settlement Across Tank Radius (Inches)</td>
</tr>
<tr>
<td>Maximum Groundwater Elevation from Surface (FT)</td>
</tr>
<tr>
<td>Coefficient of Friction Between Soil and Concrete Slab</td>
</tr>
<tr>
<td>Potential Vertical Rise, if plastic clays are present (Inches)</td>
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</tbody>
</table>

**NOTE:** Subgrade Shall NOT Contain Sulfides or Expansive Material.

<table>
<thead>
<tr>
<th>Seismic Design Information</th>
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</thead>
<tbody>
<tr>
<td>Seismic design shall be based on the applicable sections of AWWA D110-13 and IBC-2012.</td>
</tr>
</tbody>
</table>

**AWWA D110-13:**
- Importance Factor, I
- Impulsive Structural Coefficient, R_i
- Convective Structural Coefficient, R_c

**IBC – 2012:**
- Seismic Design Category
- Mapped MCE_m 5% Damped, Spectral Response Acceleration Parameter at Short Periods (S_s)(% g)
- Mapped MCE_m 5% Damped, Spectral Response Acceleration Parameter at a Period of 1 sec (S_1)(% g)
- Design, 5% Damped, Spectral Response Acceleration Parameter at Short Period (S_DS)(% g)
- Design, 5% Damped, Spectral Response Acceleration Parameter at a Period of 1 sec (S_D1)(% g)
- Soil Site Class
- Importance Factor, I_e
- Response Modification Factor, R_i
- Long Period Transition Period, T_L (Sec)