USAID | HAITI

FROM THE AMERICAN PEOPLE

# BASIS OF DESIGN REPORT

## TERRIER ROUGE HOUSING PROJECT

## DRAINAGE AND SANITATION IMPROVEMENTS
## 100% DESIGN PACKAGE

28 December 2016

**DISCLAIMER**

This publication was produced for review by the United States Agency for International Development. It was prepared by Tetra Tech.

This report was prepared for the United States Agency for International Development, USAID Contract No. EDH-I-00-08-00027-00, Task Order Number AID-521-TO-15-00001 Engineering Design and Construction Supervision Program.

**Contact Information**

[redacted]

# Table of Contents

# 1.0 GENERAL SUMMARY

This Basis of Design Report was prepared for Task Order No. 521-AID-15-0001, Engineering Design & Construction Supervision under the USAID Global Architect and Engineer Infrastructure IQC, Contract No. EDH-I-00-08-0027. Under this program, Tetra Tech provides urgent architecture and engineering (A-E) recommendations and designs, and construction supervision for the Caracol EKAM New Housing Settlement Terrier Rouge housing settlement, and the Ouanaminthe housing settlement all in the Northern Corridor.

In February 2015, Tetra Tech prepared a Special Report on the Terrier Rouge and Oaunaminthe sites to review the status and condition of the infrastructure being constructed at the two housing sites. Tetra Tech reviewed the design plans prepared by others; assessed the condition of roadway pavers, curbs, gutters, stormwater drainage, sanitation systems, and water supply and distribution systems; and provided recommendations. Two concerns of note at the Terrier Rouge site included standing water in the stormwater detention pond which presents a safety risk and promotes mosquito breeding, and poor performance of the sanitary leach fields which presents a public health risk.

USAID tasked Tetra Tech with developing designs for improvements to the stormwater drainage system and the sanitation collection and disposal systems at the Terrier Rouge location. This Basis of Design Report presents Tetra Tech's rationale and 100 percent design for the proposed stormwater and sanitation systems improvements.

## 1.1 EXISTING SANITARY SYSTEM

The Terrier Rouge sanitation system (Figure 1-1) consists of 16 communal septic tanks and associated leach fields to support 242 housing units. The original contractor was directed to install the leaching systems, which consist of plastic chambers, per the plans and specifications developed by PSA. The leaching chambers were not built according to the plans and specifications and were deemed to be not in compliance with the specified system, so the contractor was directed to replace all the systems in accordance with the design plans. At the time of the remedial construction, the construction contractor (CEEPCO) performed percolation tests in each of the system areas and informed USAID that the percolation rates were above the 120 minutes per inch which would prohibit infiltration of the effluent. The contractor was directed to replace the existing systems according to the design plans and specifications.

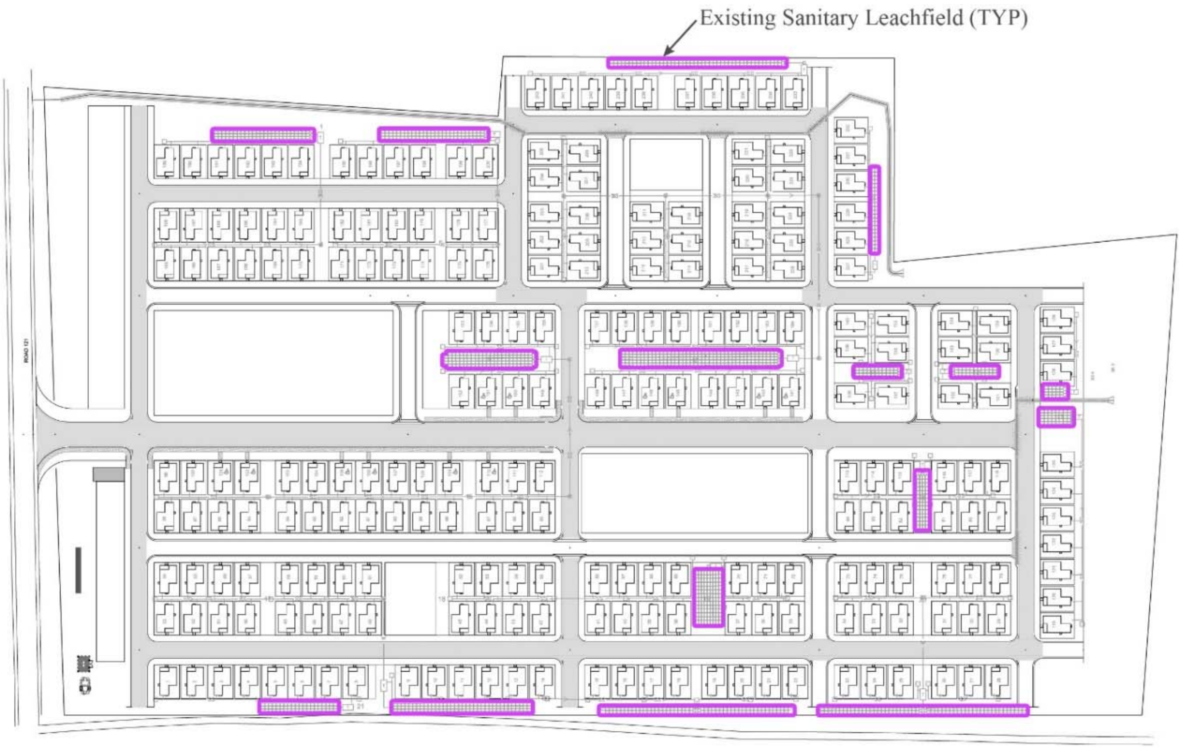



**Figure 1-1 Existing Sanitary Leaching System**

## 1.2 EXISTING DRAINAGE SYSTEM

Currently, stormwater for the Terrier Rouge site runs overland across the site where it is captured by a 7,400 cubic meter stormwater basin. Due to the tight soils and poor infiltration rates the runoff collects in the basin where small quantities evaporates or slowly infiltrates over time. The majority of the runoff remains in the basin creating a safety hazard and promoting mosquito breeding.

The Terrier Rouge site slopes downgradient in the northerly direction. Stormwater runoff is collected by roadway gutters and channels and is routed to the north portion of the site into a large pond as shown in Figure 1-2, and Figure 1-3. The original design plans prepared by others showed no proposed outlet structure for the pond, thus the original design intent likely was that collected stormwater in the pond would infiltrate over time. For this basin to perform as originally designed, stormwater would need to infiltrate into the ground prior to the next rainfall event. Given the continuous standing water present at the site, the pond is not draining as originally intended.

**Figure 1-2. Standing Water present in the Stormwater Pond**

Tetra Tech conducted a topographic survey to verify the information on the design plans and to obtain topographic information in the vicinity of the drainage pond, including on the adjacent property to the north. This additional information was required to develop the design alternatives for the proposed drainage and sanitation systems improvements.

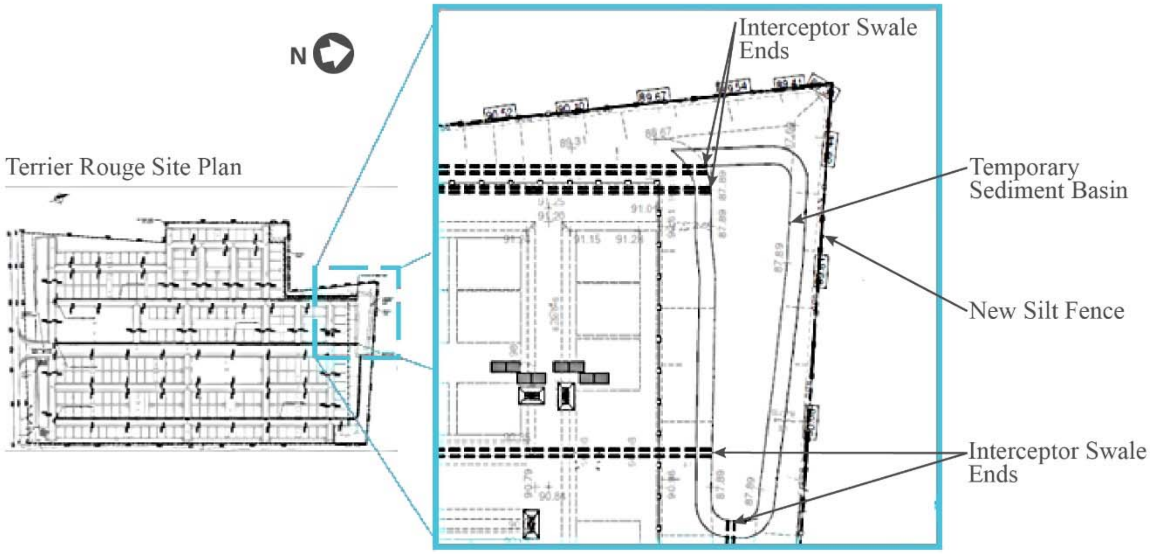



**Figure 1-3 Existing Drainage System**

# 2.0 PROPOSED IMPROVEMENTS

## 2.1 SANITARY SYSTEM IMPROVEMENTS

Tetra Tech has reviewed the project with USAID and recommends the construction of a communal sand filter to treat the effluent to an acceptable standard in accordance with the International Private Sewage Disposal Code (IPSDC). Sand filters are similar to leach fields but contain an underdrain and provide filtration, aeration and biological treatment within the filter before being discharged. The only other alternative considered was individual sand filters at each of the 16 septic fields, however the communal sand filter design was USAID's preferred option.

Figure 2-1 illustrates Tetra Tech's proposed sanitary system improvements which includes proposed collection pipes, holding tanks, two sand filters, and effluent pipes. The existing septic tanks and leaching facilities will be retained to provide settling, organic reduction and some subsurface disposal. The system upgrades will be connected to each of the 16 onsite septic tanks and will redirect the septic tank effluent from the existing chamber system that is unable to percolate at the original soil absorption leaching facility to the proposed multi baffled chamber and sand filter system where filtration, aeration and biological treatment will be provided. The chambers and sand filters will be located on the site of the current drainage basin which will be pumped of any standing water (if necessary) and filled in to an appropriate level to allow for construction.

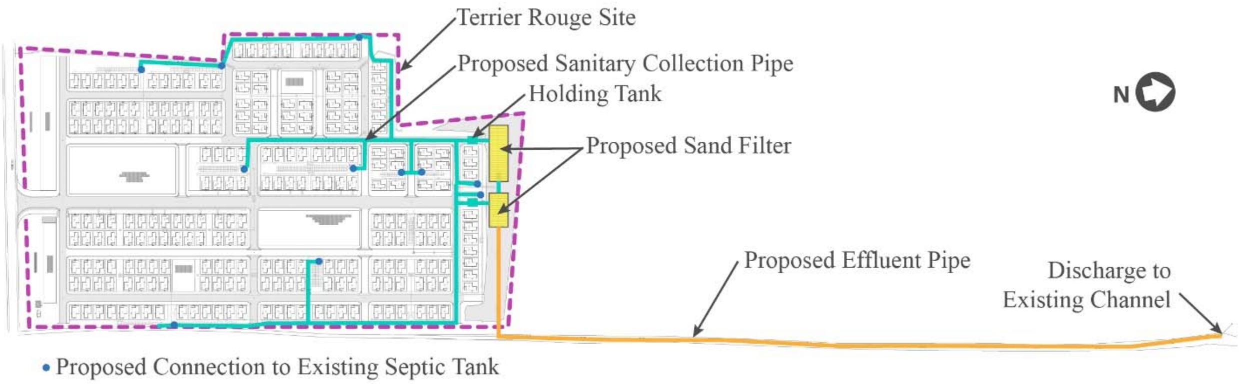



**Figure 2-1 Proposed Sanitary System**

The multi baffled chambers will further reduce the organic loading on the filters and will provide an additional 24 hours detention period.  The first sand filter bed provides treatment for 152 dwellings and has an area of 705 M2. The second provides treatment for 90 dwellings and has an area of 405 M2. The total flow to the system is 24,200 gallons per day (GPD) and both beds provide a hydraulic loading rate within the 80 to 200 l/sm/day  gal/m2/day (2 to 5 gpd/sf) standards as described in the EPA Wastewater Technology Fact Sheet for Intermittent Sand Filters. In addition, grease traps or holding tanks are to be located just prior to the leaching fields to allow for additional settling of any solids that make it past the existing septic tanks. As part of maintenance of the systems, the septic tanks and holding tanks will need to be pumped out regularly.

Effluent will be discharged through an outlet pipe to a channel approximately 650 meters downgradient. The proposed effluent pipe follows an existing dirt road to the existing channel. The dirt road is on an abutting property, and access to this area will need to be obtained prior to making the proposed improvements.

For the design of repairs and upgrades, the "September 1999" and the International Building Code (IBC) and the IPSDC was used. For items that are not covered by IBC codes, relevant US guidelines or standards were used. USAID's guiding principles were to provide the minimum acceptable standards, to avoid overdesign, and to avoid unnecessarily increasing the cost of the units.

Table 1 summarizes the site system design parameters. The design analysis of each parameter is discussed below.

**Table 1 Design Criteria**

| Design Parameter | Value | Units | Ref |
|---|---|---|---|
| # Houses/Dwelling Units | 242 | Houses | N/A |
| Average Daily Flow per Dwelling Unit | 100 | GPD /House | |
| Average Daily Flow | 24,200 | GPD | Projected calculation |
| Peaking Flow Factor | 5 | | Unified Facility Criteria UFC 3-230-03 Nov 2012 Max Hour PF =4, developed from |
| Peak Flow | 81 | GPM | Projected calculation |
| Raw BOD | 250 | mg/l | Typical domestic value |
| Raw TSS | 200 | mg/l | Typical domestic value |
| Septic Tank Effluent BOD | 175 | mg/l | 30% reduction in Septic Tank |
| Multi Baffle Chamber Effluent BOD | 60 | mg/l | 70+% reduction in Chamber |
| Sand Filter Effluent BOD | 25 | mg/l | Design Target Value |
| Sand Filter Effluent TSS | 30 | mg/l | Design Target Value |
| Effluent Fecal Coliform | 200 | #/100ml | Design Target Value |

**Table 2 Sand Filters**

| Size/other parameters | EPA Technology Fact Sheet Intermittent Sand Filters | Design |
|---|---|---|
| Typical Bed Depths (ft) | 3-4 | 3 |
| Flow Type | Septic Tank Effluent or Other Sedimentation System | ABR effluent |
| Hydraulic Loading (g/SF/day) | 2 to 5 | 2 |
| Organic Loading Rate (Lb/SF/day) | 0.0005 to 0.002 | 0.002 |

**Table 3 Gravity Sewers**

| Size/other parameters | Design Criteria | Ref | Design |
|---|---|---|---|
| Min Pipe Slope, Raw Wastewater, 3-6” piping | .4%- 1% | IPC | .4%- 1% |
| Minimum Velocity Raw Wastewater, Gravity Sewer | 2 fps, flowing full | 10 State Stnds | 2 fps |
| Manning’s” PVC pipe | 0.009 to 0.11 | | 0.010 |
| Sewer Manhole Spacing | 400 feet max. | 10 State Stnds | 400 feet max. |

Further information on the design criteria is provided below:

## Average Flow

The Average Daily Flow of 24,200 GPD is the capacity of the treatment process. The average daily flow is based on 100 GPD of domestic wastewater per dwelling unit set by USAID. This is based on the criteria that each of the 242 houses is limited to 100 GPD from the water system.

## Peak Flow

A peak flow of five times the average flow was selected for design. The criteria was established based on Unified Facility Criteria (UFC) 3-230-03 Nov 2012. Using this criteria the peak flow as 81 gallons per minute (GPM).

## Average BOD Loading

The assumed multi baffled chamber effluent BOD concentration will be 60 mg/L. This criteria was established based on the EPA Wastewater Technology Fact Sheet for Intermittent Sand Filters. At an average daily flow, the BOD daily loading rate is 12 lb/day BOD from the 242 homes.

## Sand Filters

### Filter Area

The hydraulic and organic loading rates for the sand filters follow the recommend design criteria per the EPA Fact Sheet design criteria for Intermittent Sand Filters. An approximate 2 gpd/sf loading rate and the average daily flow rate yield a required surface area of 1,070 SM for the filters. A total area of 1,072 SM is provided.

### Filter Location

The filters will be located in the area of the current stormwater pond. The basin will be filled in to allow for construction of the sand filters. The limited area does not permit the addition of a reserve area. The identified space can only include the required filter area.

The natural occurring material does not meet the needed characteristic for filter material and cannot be used. This condition requires the filter material to be hauled to the site.

### Filter Configuration and Piping

The first sand filter bed provides treatment for 152 dwellings and has an area of 705 M2. The second provides treatment for 90 dwellings and has an area of 405 M2. See Figure 2-2 below for a cross-section of the proposed sand filter.

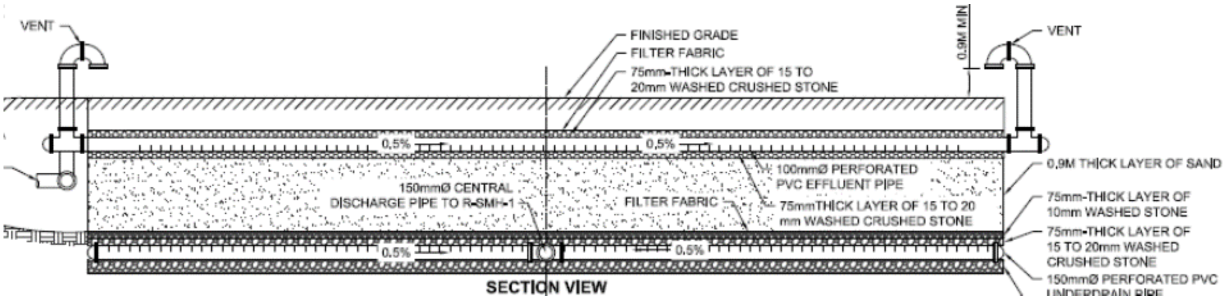



**Figure 2-2 General Sand Filter Cross-Section**

## 2.2 DRAINAGE SYSTEM IMPROVEMENTS

After reviewing the existing system with USAID, Tetra Tech and USAID came to the conclusion that filling the basin and directing the stormwater off-site was the only viable option. This will help restore the drainage pattern to generally mimic pre-development conditions. Some trenching and improvements will be required on the abutting property to accomplish this design.

Figure 2-3 illustrates Tetra Tech's proposed drainage system improvements. Paved or stone channels have been designed to connect to the existing channels and reroute the stormwater that flows to the existing basin. The existing basin will be filled in and used for the proposed sanitary sand filter area. The existing stormwater channels which inlets to the basin will be extended across the proposed sand filter area and outlet on the abutting property, which in turn replicates the pre-development conditions.

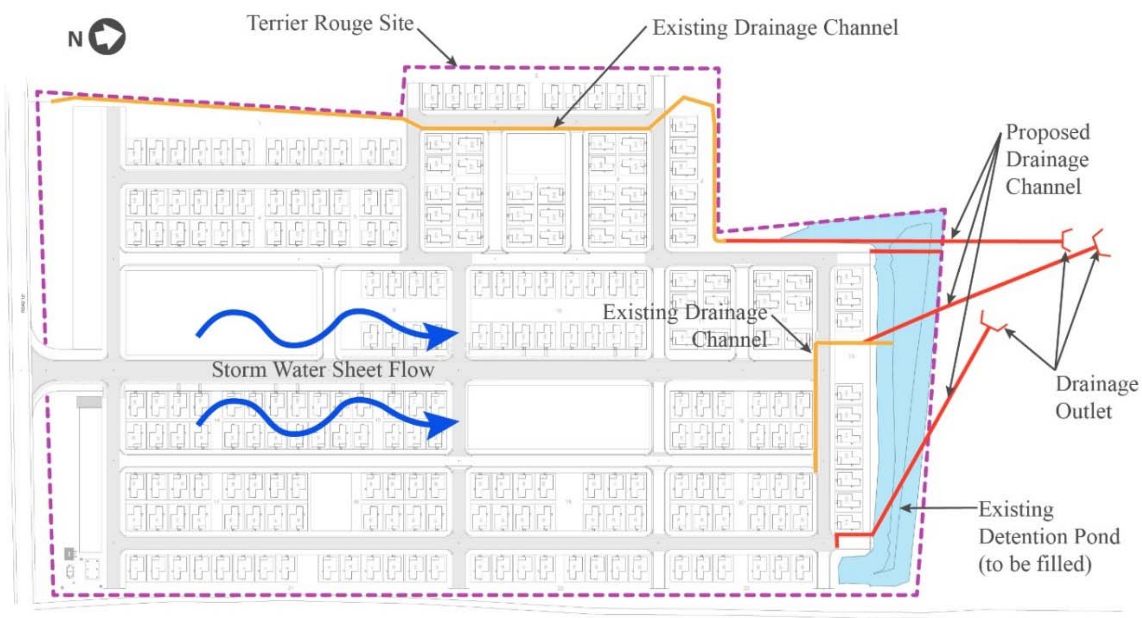



Figure 2-3 Proposed Drainage System

# ATTACHMENTS

# Flow and Area Computations

Terrier Rouge
Haiti

| Parameter | Unit | Value | Remarks |
| --- | --- | --- | --- |

## FLOW

| | | | |
| --- | --- | --- | --- |
| Building use | | | single family dwellings |
| No. of Units | | 242 | |
| Unit design flow (Local code) | GPCD | 100 | |
| Total daily flow (local code design flow) | GPD | 24200 | |

## SOIL ABSORPTION AREA

| | | | |
| --- | --- | --- | --- |
| Design perc rate | MPI | n/a | |
| Soil class | | n/a | 1=sand / loamy sand; 2=loams |
| Bed Loading Rate (min) | GPD/SF | 2.00 | |
| Bed Loading Rate (max) | GPD/SF | 5.00 | |
| Soil absorption area req'd (min) | SF | 4840 | 450 |
| **Soil absorption area req'd (max)** | **SF** | **12100** | **1124** |
| | | | |
| Soil absorption area type | | 1 | 1=bed; 2=trenches |
| length | M | 15 | Field 1 |
| width | M | 47 | Field 1 |
| length | M | 15 | Field 2 |
| width | M | 27 | Field 2 |
| **Soil absorption area provided** | **SM** | **667.5** | **Field 1** |
| **Soil absorption area provided** | **SM** | **405** | **Field 2** |
| | | **1072.5** | **Total** |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |
| | | | |

**Terrier Rouge Septic Tank Volumes**
Date: 2/18/2016

ACCORDING TO AS-BUILT DRAWINGS

| System | Tank Volume (Gal) | Houses Served | Min Vol Required (Gal) 24 Hour Storage | Preferred Vol (Gal) 48 Hour Storage |
|---|---|---|---|---|
| 1A | 2200 | 18 | 1800 | 3600 |
| 1B | 2200 | 18 | 1800 | 3600 |
| 2 | 1250 | 10 | 1000 | 2000 |
| 3 | 1250 | 6 | 600 | 1200 |
| 4 | 5000 | 36 | 3600 | 7200 |
| 5 | 5000 | 42 | 4200 | 8400 |
| 6 | 1000 | 6 | 600 | 1200 |
| 7 | 1000 | 6 | 600 | 1200 |
| 8a | 400 | 3 | 300 | 600 |
| 8b | 850 | 7 | 700 | 1400 |
| 9 | 1250 | 12 | 1200 | 2400 |
| 10 | 2200 | 22 | 2200 | 4400 |
| 11 | 5000 | 28 | 2800 | 5600 |
| 11A | 1000 | | | |
| 12 | 1250 | 10 | 1000 | 2000 |
| 13 | 2200 | 18 | 1800 | 3600 |

Note: System 11 and 11a are connected

ACCORDING TO INVOICE

| Tank Type | Quantity |
|---|---|
| Furnishing and installation of septic tank, 420 gallons capacity, pre-cast (EA) | 6 |
| Furnishing and installation of septic tank, 1,250 gallons capacity, pre-cast (EA | 3 |
| Furnishing and installation of septic tank, 5,000 gallons capacity, pre-cast (EA | 7 |

# Notes on Sewer and Drainage Calculations for Haiti – Terrier Rouge

## Sewer

The invert of the sewer outfall is restricted by the lowest cleanout elevation, which is 89.47m, just south of "LINE-9" (see Figure 1). Given this invert, it is not feasible to site the sewer outfall within the original fenceline. The remaining restriction is a minimum full-pipe flow velocity of 2 fps. The minimum slopes for the pipe sizes under consideration are shown in

**Table 1: Minimum Slopes for Full-Pipe Velocity of 2 fps.**

| Pipe Size (in) | Min Slope |
|---|---|
| 6 | 0.5% |
| 8 | 0.35% |
| 10 | 0.25% |
| 12 | 0.20% |

The resulting outfall and sewer network is shown in Figure 1.

## Drainage

For the concrete drainage chutes, the slope is dictated far more by the existence of the drainage basin than by their slopes. Therefore, to determine the requisite hydraulic capacity of any replacement structure, we look to the *upstream* earthen swale that feeds the concrete ditch. One item of note; the second-westernmost drainage chute seems unnecessary, given that the earthen ditch feeding it flows *away* from the chute, according to the proposed finished grade elevations.

The hydraulic capacity of the V-notch swale is determined from Manning's equation. Spot grades and details that show a 0.35m depth of notch indicate that the slopes and hydraulic capacities are as shown in , using 0.022 as the Manning's Roughness coefficient for an Earth channel – Clean (http://www.engineeringtoolbox.com/mannings-roughness-d_799.html):

For structure IL1-OL1, spot grades on the existing ground surface demonstrate that the pipe can follow the same path and daylight before exiting the property. The starting inlet elevation is given on the plan. The intersection of the property boundary with the extension of the drainage ditch's thalweg indicates the location of the ending spot grade on the existing surface. The requisite pipe and ditch size for conveying the flow calculated in Table 2 for this structure are shown in Table 3.

The remaining three structures will not daylight before hitting the property boundary if their current bearing is maintained, regardless of slope. We reroute these structures such that their bearing is perpendicular to the contours (i.e., parallel to the steepest direction of ground slope). Even while chasing the steepest ground slope, the eastern 3 structures cannot daylight before hitting the property boundary.

As a potential solution, we provide the elevation at the property boundary and at the boundary of the proposed future wetlands. We then continue the path of the structures along the steepest ground slope, through the extended contours until the structures daylight. We maintain a minimum slope of 0.5%. The resulting outlet locations required are shown in Figure 1. The requisite pipe size/ditch width for maintaining hydraulic capacity is shown in Table 4.

**Table 2: Hydraulic Capacity Requirements Of Proposed Structures Based On Upstream Contributions**

| Structure | Nearest Upstream Spotgrade 2 (m) | Nearest Upstream Spotgrade 1 (m) | Distance (m) P2 to P1 | Slope P2 to P1 | Hydraulic Capacity $m^3/s$ |
|---|---|---|---|---|---|
| IL1-OL1 | 90.79 | 90.61 | 16.6 | 0.011 | 0.73 |
| S1-OL3B | 88.54 | 87.47 | 46.6 | 0.023 | 1.13 |
| IL4-OL4B | 90.40 | 90.26 | 16.0 | 0.0088 | 0.66 |
| IL5-OL5B | 90.46 | 90.25 | 25.0 | 0.0084 | 0.64 |

**Table 3: Requisite Pipe and Ditch Size for Daylighting Structures: Unmodified Bearings**

| Structure | Upstream Invert | Downstream Spot Grade | Distance P2 to P1 | Slope P2 to P1 | Required Hydraulic Capacity $m^3/s$ | Min Pipe Diameter (mm) | Available Pipe Diameter (in) | Min Ditch Top Width (m) | Design Ditch Top Width (m) |
|---|---|---|---|---|---|---|---|---|---|
| IL1-OL1 | 90.61 | 89.51 | 30.86 | 0.036 | 0.42 | 0.397 | 16" | 0.746 | 0.75 |

**Table 4: Requisite Pipe and Ditch Size for Daylighting Structures: Modified Bearings**

| Structure | Slope | Required Hydraulic Capacity $m^3/s$ | Min Pipe Diameter (mm) | Available Pipe Diameter (in) | Min Ditch Top Width (m) | Design Ditch Top Width (m) |
|---|---|---|---|---|---|---|
| S1-OL3B | 0.50% | 1.13 | 0.833 | 36 | 1.63 | 1.65 |
| IL4-OL4B | 0.50% | 0.66 | 0.681 | 27 | 1.33 | 1.35 |
| IL5-OL5B | 0.50% | 0.64 | 0.670 | 27 | 1.31 | 1.35 |

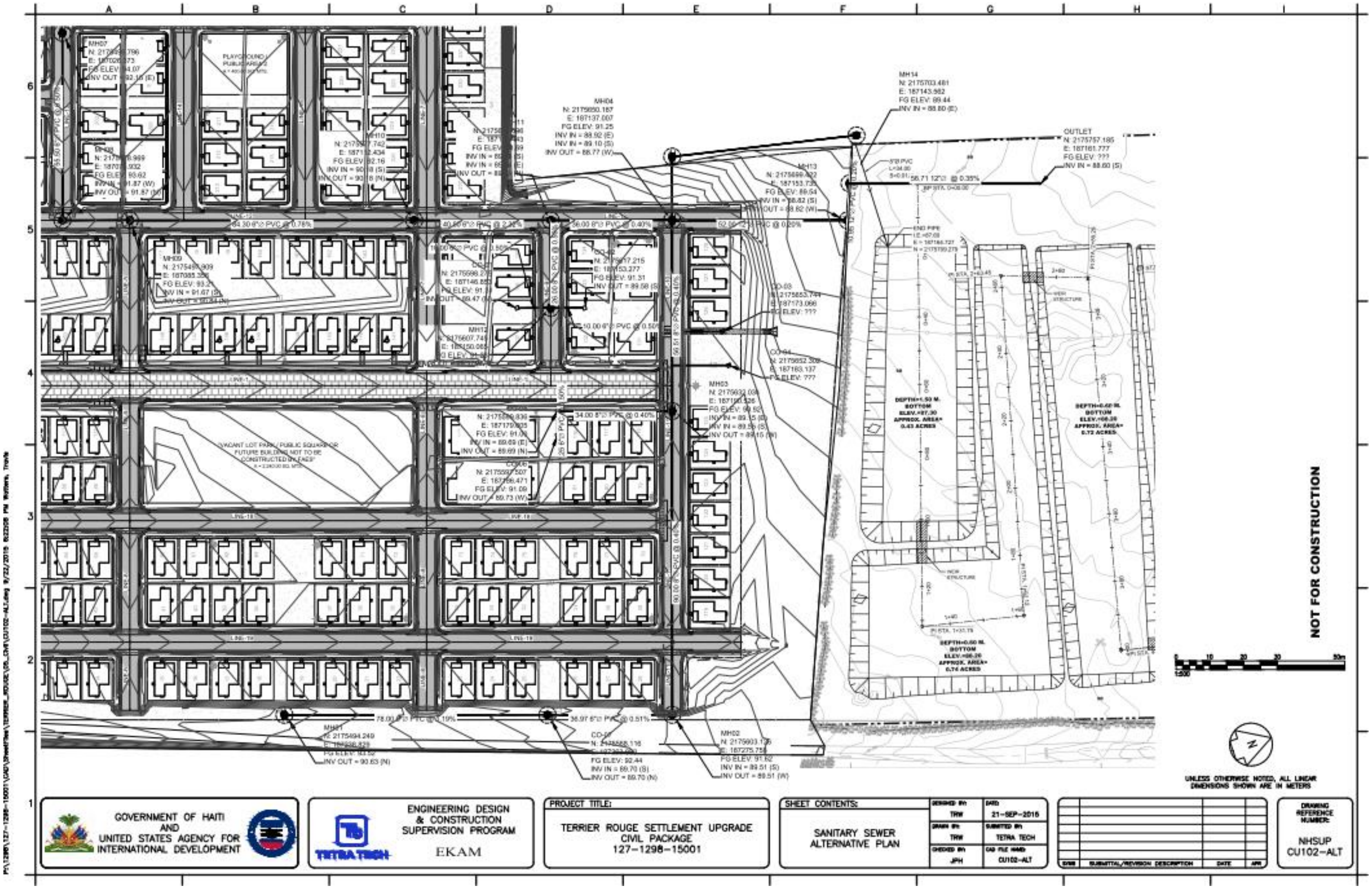
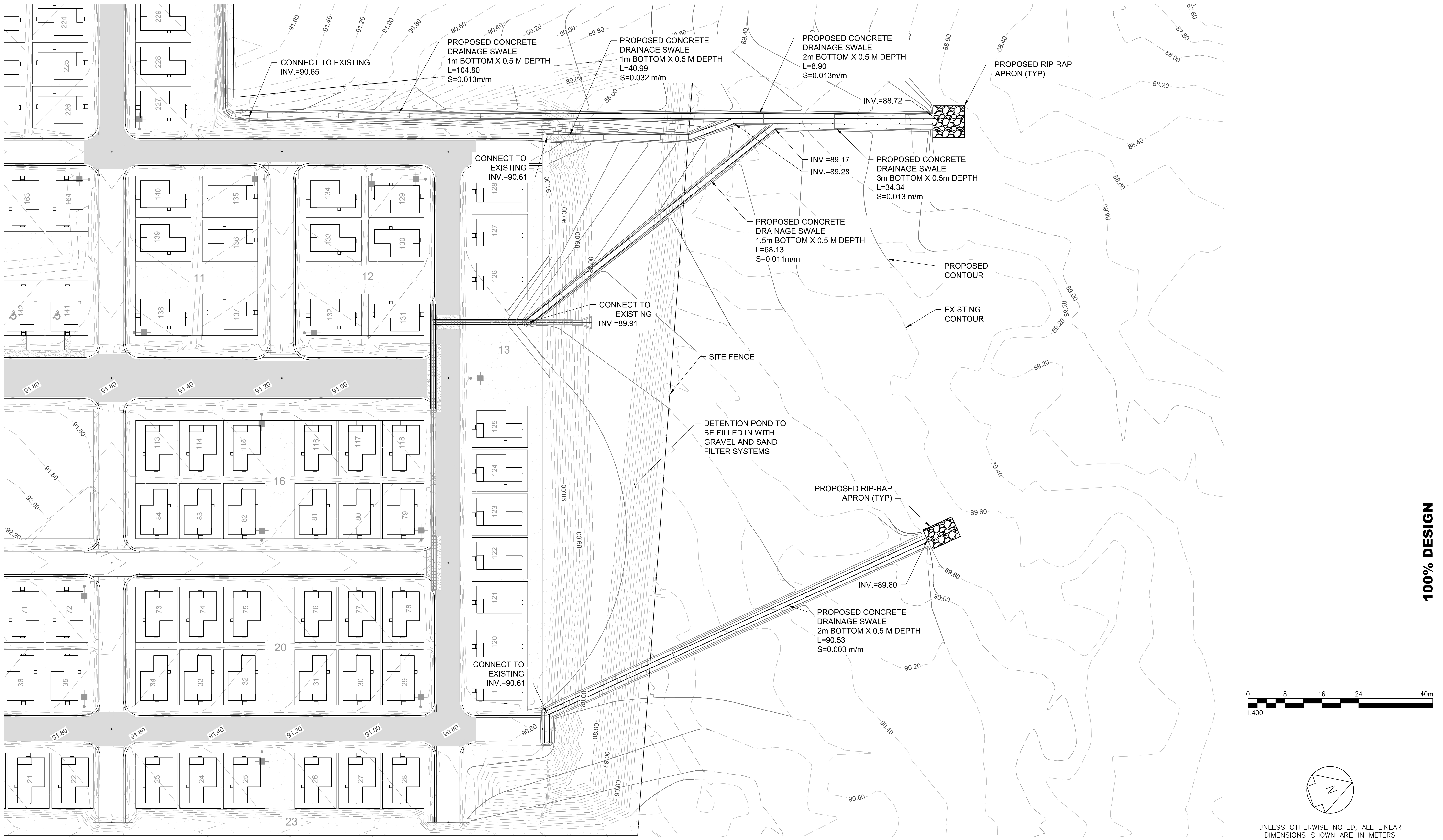



Figure 1: Sanitary Sewer Alternative Plan




UNLESS OTHERWISE NOTED, ALL LINEAR DIMENSIONS SHOWN ARE IN METERS

GOVERNMENT OF HAITI
AND
UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT

TETRA TECH

ENGINEERING DESIGN & CONSTRUCTION SUPERVISION PROGRAM
TERRIER ROUGE

PROJECT TITLE:
TERRIER ROUGE SETTLEMENT UPGRADE
CIVIL PACKAGE
127-1298-15001

SHEET CONTENTS:
GRADING AND DRAINAGE PLAN

| | |
|---|---|
| DESIGNED BY: AMM | DATE: 26-DEC-2016 |
| DRAWN BY: AMM | SUBMITTED BY: TETRA TECH |
| CHECKED BY: JWH | CAD FILE NAME: ROUGE-CD-101 |

| SYMB | SUBMITTAL/REVISION DESCRIPTION | DATE | APR |
|---|---|---|---|

DRAWING REFERENCE NUMBER:
ROUGE CD-101

\\NES011FS1\Projects\1298\127-1298-15001\CAD\SheetFiles\TERRIER_ROUGE\05_Civil\ROUGE-CD-101.dwg 12/19/2016 10:47:49 AM Catano, Nicholas

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**

AASHTO LRFD Bridge Design Specifications 4th Edition, 2007
ACI 318-08
ACI 350-06

**Notes:**

**Since cover is more than 2 feet, H20 wheel load is considered as uniformly distributed.**

## General

1. AT REST EARTH PRESSURE IS ASSUMED.
2. THE MONONOBE-OKABE APPROACH IS USED TO GET THE LATERAL EARTH PRESSURE CAUSED BY EARTHQUAKE
3. SANITARY COEFFICIENTS ARE INCLUDED IN DESIGN
4. CONSIDER WALL HINGED TOP AND BOTTOM
5. SEISMIC COEFFICIENTS: Ss=1.50g AND S1= 0.60g.
6. ASSUME GROUND WATER ELEVATION IS 5.0M BELOW GRADE U.N.O. DUE TO SITE SPECIFIC TESTS
7. DESIGN LOAD ON ROOF SLAB: AASHTO H20 PER AASHTO SPECIFICATION
8. LIVE LOAD IMPACT WILL NOT BE INCLUDED
9. ROOF SLAB: HINGED FOUR SIDES
10. TWO FEET LIVE LOAD SURCHARGE ON THE TANK WALLS.
11. CORROSION RESISTANT CONCRETE OR CEMENT SHOULD BE USED, TYPE II CEMENT
12. BOTTOM SLAB: HINGED FOUR SIDES
13. PER ACI 350 - SECTION 7.12.2.2, MINIMUM FLEXURE REINFORCEMENT IS 13MM AND NOT MORE THAN 300MM APART.
14.THE SAFETY FACTOR FOR FLOTATION IS 1.25; ACI 350.4R-04 SECTION 3.1.2
15. LOAD COMBINATION PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS 4TH EDITION
16. TIRE CONTACT AREA IS 10 INCHES x 20 INCHES: AASHTO 3.6.1.2.5

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

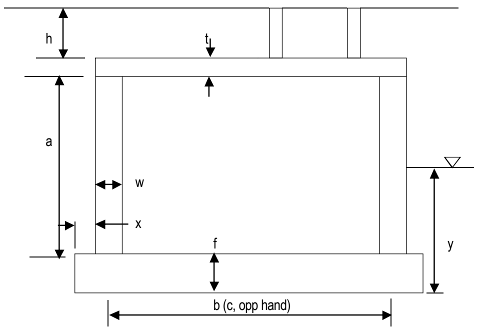
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Geometry

GEOMETRY INFORMATION INPUT:

| | | | | |
|---|---|---|---|---|
| WALL HEIGHT, a: | 8.20 | ft | 2500 | mm |
| LONG WALL LENGTH, b: | 14.11 | ft | 4300 | mm |
| R.S. AND F.S. SPAN =SHORT WALL LENGTH, c: | 10.83 | ft | 3300 | mm |
| WALL THICKNESS, w: | 0.98 | ft | 300 | mm |
| TOP SLAB THICKNESS, t: | 1.31 | ft | 400 | mm |
| BOT SLAB THICKNESS, f: | 1.31 | ft | 400 | mm |
| DEPTH OF FILL ABOVE ROOF SLAB, h: | 5.91 | ft | 1800 | mm |
| HEIGHT OF WATER ABOVE BASE, y: | 0.00 | ft | 0 | mm |
| LENGTH OF FTG EXTENSION, x: | 0.00 | ft | 0 | mm |



# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Additional Input Parameters

GEOTECHNICAL INFORMATION:

| | | | | |
|---|---|---|---|---|
| WEIGHT OF SOIL BACKFILL (Dry), gsoil: | 115.00 | Lbs/CF | | |
| WEIGHT OF SOIL BACKFILL (Saturated): | 135.00 | Lbs/CF | | |
| ALLOWABLE BEARING CAPACITY: | 2.00 | ksf | | |
| PHI: FRICTION ANGLE OF BACKFILL: | 20.90 | DEG | RAD = | 0.3648 |
| AT REST PRESSURE COEFF, Ko | 0.50 | | | |
| ACTIVE PRESSURE COEFF, Ka: | 0.30 | | | |
| LIVE LOAD SURCHARGE CONSIDERED: | YES | | | |

| WALL LOADING CONDITION TWO | | | WALL LOADING CONDITION ONE | | |
|---|---|---|---|---|---|
| HEIGHT SOIL ABOVE BOT SLAB EXT - WET: | 0.00 | ft | HEIGHT SOIL ABOVE BOT SLAB EXT - WET: | 0.00 | ft |
| HEIGHT SOIL ABOVE BOT SLAB EXT - DRY: | 0.00 | ft | HEIGHT SOIL ABOVE BOT SLAB EXT - DRY: | 15.42 | ft |
| HEIGHT SOIL ON TOP SLAB - WET: | 0.00 | ft | HEIGHT SOIL ON TOP SLAB - WET: | 0.00 | ft |
| HEIGHT SOIL ON TOP SLAB - DRY: | 5.91 | ft | HEIGHT SOIL ON TOP SLAB - DRY: | 5.91 | ft |

MATERIAL PROPERTIES:

| | | |
|---|---|---|
| CUBIC WEIGHT CONCRETE=wconc: | 150.00 | Lbs/CF |
| COMP. STRENGTH OF CONC. = F'c: | 4.00 | ksi |
| TENSILE STRENGTH OF REBAR = Fy: | 60.00 | ksi |
| WEIGHT OF WATER = ww: | 62.40 | Lbs/CF |

Design Strength Factors - Environmental Durability Factor (ACI 350-06 R9.2.6)

| | |
|---|---|
| ϕ , Flexure: | 0.90 |
| ϕ , Shear: | 0.75 |

| Environmental Durability Factor (ACI 350-06 EQ 9-8): | ROOF SLAB | WALL CASE 1 | | WALL CASE 2 | | WALL CASE 3** | | BASE SLAB |
|---|---|---|---|---|---|---|---|---|
| | | Top | Bottom | Top | Bottom | Top | Bottom | |
| FLEXURE: | 2.08 | 1.99 | 1.57 | 1.99 | 1.99 | n/a | n/a | 2.20 |
| SHEAR: | 1.47 | 1.41 | 1.11 | 1.41 | 1.41 | n/a | n/a | 1.56 |

ENVIRONMENTAL EXPOSURE: SEVERE

**Note: No Sd for Seismic load combinations ACI 350 Section 21.2.1.8

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Dead Load

| | | | | |
|---|---|---|---|---|
| DL1, ROOF SLAB: | 233.92 | cf conc = | 35.09 | kips |
| DL2, WALLS: | 402.59 | cf conc = | 60.39 | kips |
| DL3, BOTTOM SLAB: | 233.92 | cf conc = | 35.09 | kips |
| DL5, SOIL ON FTG EXT - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL6, SOIL ON FTG EXT - DRY: | 0.00 | cf soil = | 0.00 | kips |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL8, SOIL ON TOP SLAB - DRY: | 1052.66 | cf soil = | 121.06 | kips |
| TOTAL DL CONC: | | | 130.57 | kips |
| TOTAL DL SOIL: | | | 121.06 | kips |
| TOTAL DL: | | | 251.62 | kips |

TOTAL CONCRETE QUANTITY: 32.24 cy

TOTAL SOIL QUANTITY: 38.99 cy
(only above plan limits of base slab)

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN ROOF SLAB

**Design Uniform Load:**

| | | | | |
|---|---|---|---|---|
| DL1, ROOF SLAB: | 233.92 | cf conc = | 35.09 | kips |
| TOTAL UNIFORM DL: | | | 0.20 | ksf |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL8, SOIL ON TOP SLAB - DRY: | 1052.66 | cf soil = | 121.06 | kips |
| TOTAL SL: | | | 121.06 | kips |
| TOTAL UNIFORM SL: | | | 0.68 | ksf |
| Ratio b/c = | 1.30 | | | |
| TWO WAY SLAB | YES | | **SEE AASHTO 4.6.2.1.5** | |

Per AASHTO 12.11.2.1, when the depth of fill is less than 2 ft, the wheel load shall be distributed as in slabs with concentrated loads (4.6.2.10). And also based on the distribution of the wheel load through earth fill

| | | | |
|---|---|---|---|
| DEPTH OF FILL, h: | 5.91 | ft | **SINCE THE COVER OVER THE TOP SLAB IS GREATER THAN 2 FT, THE LIVE LOAD IS DISTRIBUTED IN ACCORDANCE WITH AASHTO 4.6.2.10.** |
| DISTRIBUTE CONCENTRATED LOAD? | NO | | |
| INCLUDE LL IMPACT (AASHTO 3.6.2.1)? | NO | | . |
| LIVE LOAD IMPACT (AASHTO 3.6.2.2): | 1.00 | | |
| # WHEELS ALONG LENGTH: | 1.00 | | |
| # WHEELS ON ALONG WIDTH: | 2.00 | | |
| HI-93 WHEEL LOAD | 16.00 | kips | |
| DISTRIBUTION WDITH, SHORT SIDE, d1: | 10.83 | ft | <=== Quick check, this dist should be less than 22.34 ft, which would be dist length if areas don't overlap |
| DISTRIBUTION WDITH, LONG SIDE, d2: | 12.00 | ft | <=== Quick check, this dist should be less than 12.00 ft, which would be dist length if areas don't overlap |
| TOTAL UNIFORM LIVE LOAD, wl: | 0.25 | ksf | |
| TOTAL LIVE LOAD: | 32.00 | kips | |

**AASHTO 3.24.6.1 -- Slab supported on four sides**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| For concentrated load at center: | p = | 0.74 | of Total Load | For concentrated load at center: | p = | 0.26 | of Total Load |
| For Uniformly distributed load: | p = | 0.69 | of Total Load | For Uniformly distributed load: | p = | 0.31 | of Total Load |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Roof Slab:**

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov ($in^2$) |
|---|---|---|---|---|---|
| Short Direction, Bottom | 25.00 | 0.7609 | 0.9843 | 5.12 | 1.78 |
| Long Dir, Bottom | 20.00 | 0.4869 | 0.7874 | 5.12 | 1.14 |

**Verify long rebar meets AASHTO 5.14.4**

| | | | |
|---|---|---|---|
| % Distribution Steel = | 30.39 | % | |
| As long required = | 0.54 | $in^2$ | |
| As long provided = | 1.14 | $in^2$ | **OK** |

**First, consider steel in short direction.**

Positive moment - Center - (Rebar at Bottom of Slab)

| | | |
|---|---|---|
| qunfact = DL + LL + SL | 1122.26 | psf |
| qfact =(1.2DL+1.6LL+1.6SL) | 1716.88 | psf |
| $S_d$: | 2.08 | |
| M+Coeff: | 0.125 | |
| M+=MCoeff*q*c$^2$/1000*$S_d$: | 35.97 | ft*kips |

| | | |
|---|---|---|
| Top Slab Thickness: | 1.31 | ft |
| Cover = | 2.00 | in. |
| d (M+) short = | 13.26 | in. = t - cover - 1/2db(short) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of slab) |

Check Moment Capacity (M+):

| | | | |
|---|---|---|---|
| As T & S= | 0.34 | in2 | =0.0018bh |
| Asprov = | 1.78 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 2.62 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 95.89 | kip*ft | |
| M+ = | 35.97 | **POS MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Roof Slab Cont.:**

**Next, consider steel in long direction.**

Positive moment - Center - (Rebar at Bottom of Slab)

| | | | |
|---|---|---|---|
| qunfact = DL + LL + SL | 1122.26 | psf | |
| qfact =(1.2DL+1.6LL+1.6SL) | 1716.88 | psf | |
| $S_d$: | 2.08 | | |
| M+Coeff: | 0.125 | | |
| M+=MCoeff*q*c$^2$/1000*$S_d$: | 27.61 | ft*kips | |
| d (M+) long = | 12.37 | in. = t - cover - db(short) - 1/2db(long) | |
| f'c = | 4.00 | ksi | |
| bw = | 12.00 | (per linear ft of slab) | |

Check Moment Capacity (M+):

| | | | |
|---|---|---|---|
| As T & S= | 0.34 | in2 | =0.0018bh |
| Asprov = | 1.14 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.68 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 59.23 | kip*ft | |
| M+ = | 27.61 | **POS MOMENT CAPACITY O.K.** | |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

Unfactored Moment:

| | | | | | |
|---|---|---|---|---|---|
| qunfact =(DL+LL+SL) | 1.12 | ksf | qunfact =(DL+LL+SL) | 1.12 | ksf |
| M+ unfactored= | 16.44 | ft*kips | M+ unfactored= | 27.92 | ft*kips |

| Crack Check (M+ bottom face short reinf.): | | | Crack Check (M+ bottom face long reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 1.78 | in2 | Asprov = | 1.14 | in2 |
| d= | 13.26 | in | d= | 12.37 | in |
| n= | 8.04 | | n= | 8.04 | |
| ρ= | 0.011 | | ρ= | 0.008 | |
| ρn= | 0.090 | | ρn= | 0.062 | |
| k= | 0.344 | | k= | 0.295 | |
| j= | 0.885 | | j= | 0.902 | |
| M+ unfactored= | 16.444 | kips.ft | M+ unfactored= | 27.920 | kips.ft |
| fs= | 9.425 | ksi | fs= | 26.315 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 5.118 | in | s= | 5.118 | in |
| db= | 0.984 | in | db= | 0.787 | in |
| fs,max= | 26.958 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 27.481 | **INSIDE FACE BAR SPACING O.K.** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Check Shear Capacity of Top Slab**

| | | | |
|---|---|---|---|
| qunfact = DL + LL + SL | 1.12 | ksf | |
| qfact =(1.2DL+1.6LL+1.6SL) | 1.72 | ksf | |
| $S_d$: | 1.47 | | |
| Csmax = | 0.50 | | |
| phiv = | 0.75 | | |
| d = | 13.26 | in. = t - cover - 1/2db(short) | |
| f'c = | 4.00 | ksi | |
| bw = | 12.00 | (per linear ft of wall) | |

Check Shear in Roof Slab

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 20.12 | kips |
| PHI*Vc = | 15.09 | kips |
| Vu = Cs*q*c*$S_d$ | 13.67 | **SHEAR CAPACITY O.K.** |

Shear Friction

| | | | |
|---|---|---|---|
| u: | 1.000 | | 11.6.4.3 |
| phiv: | 0.75 | | |
| Avf (req'd)=Vu/(Fy*u*phi): | 0.30 | $in^2$ | |
| As (provided): | 1.78 | $in^2$ | **OK** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN WALLS

| | | | |
|---|---|---|---|
| ww = | 62.40 | pcf | |
| Wall clear height a = | 8.20 | ft | |
| Wall thickness, w= | 11.81 | in | Use at rest Soil pressure Ko |
| Bottom slab thickness f = | 1.31 | ft | |
| qw = ww*a | 511.81 | psf | |

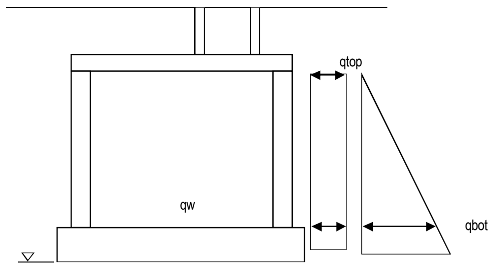
# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 1 - Tank is full and Water Table below the invert of the structure - Lateral Earth Pressure + 2ft LL Surcharge

| | | | | | |
|---|---|---|---|---|---|
| ww = | 62.40 | pcf | Soil pressure | | |
| Wall clear height a = | 8.20 | ft | qsoil top = | 530.03 | psf |
| Wall thickness, w= | 11.81 | in | qsoil bot = | 1001.65 | psf |
| qwtop = ww*a | 0.00 | psf | | | |
| qwbot= ww*a | 511.81 | psf | | | |




| | | |
|---|---|---|
| qtop_unfact = | 530.03 | psf |
| qbot_unfact = | 489.84 | psf |
| qtop_fact: 1.6*qsoiltop + 1.2*qwtop = | 848.04 | psf |
| qbot_fact: 1.6*qsoilbot + 1.2*qwbot = | 988.46 | psf |

| Environmental Durability Factor, Sd: | Flexure | Shear |
|---|---|---|
| Sd_top = | 1.99 | 1.41 |
| Sd_bot = | 1.57 | 1.11 |

| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 1.32 | SAY ====> | 1.25 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -45 |
| +My | 53 | 48 |
| -Mx | -51 | -45 |
| +Mx | 91 | 63 |
| Vside max | 0.37 | 0.36 |
| Vbot | 0.45 | 0.39 |
| Vtop | 0.45 | 0.39 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_d$ = | 0.75 | ksf | |
| | qbotfact * $S_d$ = | 0.55 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 1.96 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 2.38 | klf | <== Shear at top of wall is tensile force (Nu) in roof slab |
| | Vubot = | 2.38 | klf | <== Shear at bottom of wall is tensile force or compression force (Nu) in base slab |

Tension reinforcement requirement for floor slab and roof slab:

| | | | | |
|---|---|---|---|---|
| | Tubot = | 2.38 | klf | |
| | Tutop = | 2.38 | klf | |
| | phiT= | 0.90 | | |
| Bot slab | Ast =Tu/(Fy*phiT): | 0.044 | in^2/ft | **Main Reinforcement Direction** |
| Top slab | Ast =Tu/(Fy*phiT): | 0.044 | in^2/ft | **Main Reinforcement Direction** |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_d$ = | 1.05 | ksf | |
| | qbotfact * $S_d$ = | 0.77 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -3.13 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 5.58 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -3.13 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 3.25 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

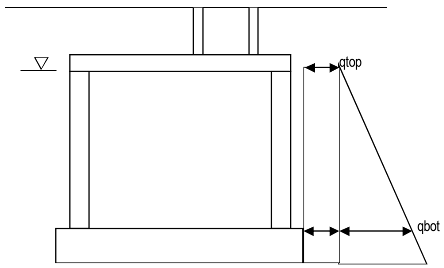
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 2 - Tank is empty and water table at its highest elevation - Lateral Earth Pressure + 2ft LL Surcharge

| | qtop | | qbot | |
|---|---|---|---|---|
| Surcharge = | 115.00 | psf | 115.00 | psf |
| Soil = | 415.03 | psf | 886.65 | psf |
| Wet Soil = | 0.00 | psf | 0.00 | psf |
| Water = | 0.00 | psf | 0.00 | psf |

| | | |
|---|---|---|
| qtop_unfact = | 530.03 | psf |
| qbot_unfact = | 1001.65 | psf |
| qtop_fact: 1.6*qtop_unfact = | 848.04 | psf |
| qbot_fact: 1.6*qbot_unfact = | 1602.64 | psf |




| Environmental Durability Factor, Sd: | Flexure | Shear |
|---|---|---|
| Sd_top = | 1.99 | 1.41 |
| Sd_bot = | 1.99 | 1.41 |

| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 1.32 | SAY ====> | 1.25 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -45 |
| +My | 53 | 48 |
| -Mx | -51 | -45 |
| +Mx | 91 | 63 |
| Vside max | 0.37 | 0.36 |
| Vbot | 0.45 | 0.39 |
| Vtop | 0.45 | 0.39 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 5 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -30 | -26 |
| +My | 30 | 27 |
| -Mx | -30 | -26 |
| +Mx | 48 | 35 |
| Vside max | 0.2 | 0.2 |
| Vbot | 0.31 | 0.27 |
| Vtop | 0.14 | 0.11 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_{d=}$ | 1.19 | ksf | |
| | qbotfact * $S_{d=}$ | 2.25 | ksf | |
| | qtopfact - qbotfact = | 1.06 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 5.36 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 5.62 | klf | <== Shear at top of wall is compressiom (Nu) in roof slab |
| | Vubot = | 7.10 | klf | <== Shear at bottom of wall is compressiom (Nu) in base slab |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_{d=}$ | 1.68 | ksf | |
| | qbotfact * $S_{d=}$ | 3.18 | ksf | |
| | qtopfact - qbotfact = | 1.50 | | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.80 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 15.14 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.80 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 9.03 | k.ft/ft | **Inside Face Reinforcement** |

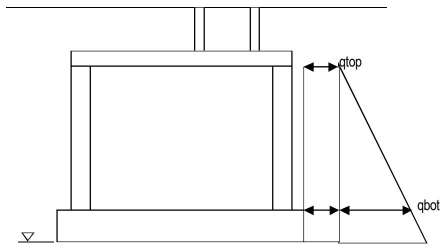
# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 3 - Under Seismic Loads + 2ft LL Surcharge

| | | |
|---|---|---|
| qltop = | 115.00 | psf |
| qlbot = | 115.00 | psf |
| qetop = | 1372.49 | psf |
| qebot = | 1372.49 | psf |
| qtop_unfact = | 1487.49 | psf |
| qbot_unfact = | 1487.49 | psf |
| qtop_fact: 1.6*qltop + 1.0*qetop = | 1556.49 | psf |
| qbot_fact: 1.6*qlbot + 1.0*qebot = | 1556.49 | psf |




| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 1.32 | SAY ====> | 1.25 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -45 |
| +My | 53 | 48 |
| -Mx | -51 | -45 |
| +Mx | 91 | 63 |
| Vside max | 0.37 | 0.36 |
| Vbot | 0.45 | 0.39 |
| Vtop | 0.45 | 0.39 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact = | 1.56 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | qbotfact = | 1.56 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside = | 4.72 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 5.74 | klf | <== Shear at top of wall is compressiom (Nu) in roof slab |
| | Vubot = | 5.74 | klf | <== Shear at bottom of wall is compressiom (Nu) in base slab |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact = | 1.56 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | qbotfact = | 1.56 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -5.34 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 9.53 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -5.34 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 5.55 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN WALL REINFORCEMENT

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov ($in^2$) |
|---|---|---|---|---|---|
| Wall - Vertical (outside) | 20.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Horiz (outside) | 20.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Vertical (inside) | 20.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Horiz (inside) | 20.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |

**Check Shear Capacity:**

| DESIGN LOADS | Load Case 1 | Load Case 2 | Load Case 3 | Max (kips) |
|---|---|---|---|---|
| Vubot, total: | 2.38 | 7.10 | 5.74 | 7.10 |
| Vutop, total: | 2.38 | 5.62 | 5.74 | 5.74 |
| Vuside, total: | 1.96 | 5.36 | 4.72 | 5.36 |

| | | |
|---|---|---|
| phiv = | 0.75 | |
| Wall Thickness, w: | 0.98 | ft |
| Cover = | 2.00 | in. |
| d (M+) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of wall) |

| | | |
|---|---|---|
| d (M+) horiz = | 8.87 | in. = w - cover - db(vert) - 1/2db(horiz) |

Check Shear in Tank Wall - top/bot

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 14.41 | kips |
| PHI*Vc = | 10.81 | kips |
| Vubot = | 7.10 | **SHEAR CAPACITY O.K.** |

Check Shear in Tank Wall - side

| | | |
|---|---|---|
| Vc = 2*(1)*f'c^.5*bw*d | 13.46 | kips |
| PHI*Vc = | 10.09 | kips |
| Vubot = | 5.36 | **SHEAR CAPACITY O.K.** |

Shear Friction

| | | | |
|---|---|---|---|
| u: | 1.000 | | 11.6.4.3 |
| phiv: | 0.75 | | |
| Avf (req'd)=Vu/(Fy*u*phi): | 0.16 | $in^2$ | |
| As (provided): | 0.56 | $in^2$ | **OK** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Check Flexural Capacity:**

| Steel | DESIGN LOADS | Load Case 1 | Load Case 2 | Load Case 3 |
|---|---|---|---|---|
| Vertical | Mu+ inside face reinf. | 5.58 | 15.14 | 9.53 |
| | Mu- outside face reinf. | -3.13 | -8.80 | -5.34 |
| Horizontal | Mu+ inside face reinf. | 3.25 | 9.03 | 5.55 |
| | Mu- outside face reinf. | -3.13 | -8.80 | -5.34 |

| Max (k*ft) | Max (kip*in) |
|---|---|
| 15.14 | 181.74 |
| -8.80 | -105.60 |
| 9.03 | 108.32 |
| -8.80 | -105.60 |

**Design for Vertical Bending Moments (determine Vertical Steel):**

| | | |
|---|---|---|
| Wall Thickness, w: | 0.98 | ft |
| Cover (inside) = | 2.00 | in. |
| d (M+) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| d (M+) horiz = | 8.87 | in. = w - cover - db(vert) - 1/2db(horiz) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of slab) |

| | | |
|---|---|---|
| Cover (outside) = | 2.00 | in. |
| d (M-) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| d (M-) horiz = | 8.87 | in. = w - cover - db(vert) - 1/2db(horiz) |

Check Moment Capacity (Mu+ inside face reinf. ):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| Asprov = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 22.84 | kip*ft | |
| Mu+ inside face reinf= | 15.14 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu- outside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| As = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 22.84 | kip*ft | |
| ABS Mu- ourside face= | 8.80 | **NEG MOMENT CAPACITY O.K.** | |

**Next, consider steel in horizontal direction.**

Check Moment Capacity (Mu+ inside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| Asprov = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 21.26 | kip*ft | |
| Mu+ inside face reinf= | 9.03 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu- outside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| As = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 21.26 | kip*ft | |
| ABS Mu- ourside face= | 8.80 | **NEG MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

| Unfactored Moment: | Load Case 1 | Load Case 2 | Load Case 3 |
|---|---|---|---|
| M+ vert unfactored= | 1.65 | 4.49 | 9.11 |
| M- vert unfactored= | -0.93 | -2.61 | -5.10 |
| M+ horiz unfactored= | 0.96 | 2.67 | 5.30 |
| M- horiz unfactored= | -0.93 | -2.61 | -5.10 |

| Crack Check (M+ inside face vertical reinf.): | | | Crack Check (Mu- outside face vertical reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 0.56 | in2 | As = | 0.56 | in2 |
| d= | 9.50 | in | d= | 9.50 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.015 | | ρ= | 0.015 | |
| ρn= | 0.118 | | ρn= | 0.118 | |
| k= | 0.382 | | k= | 0.382 | |
| j= | 0.873 | | j= | 0.873 | |
| M+ unfactored= | 9.106 | kips.ft | M- unfactored= | 5.104 | kips.ft |
| fs= | 23.606 | ksi | fs= | 13.230 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 6.693 | in | s= | 6.693 | in |
| db= | 0.630 | in | db= | 0.630 | in |
| fs,max= | 23.665 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 23.665 | **OUTSIDE FACE BAR SPACING O.K.** |

| Crack Check (M+ inside face horiz reinf.): | | | Crack Check (Mu- outside face horiz reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 0.56 | in2 | As = | 0.56 | in2 |
| d= | 8.87 | in | d= | 8.87 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.016 | | ρ= | 0.016 | |
| ρn= | 0.127 | | ρn= | 0.127 | |
| k= | 0.392 | | k= | 0.392 | |
| j= | 0.869 | | j= | 0.869 | |
| M+ unfactored= | 5.304 | kips.ft | M- unfactored= | 5.104 | kips.ft |
| fs= | 14.782 | ksi | fs= | 14.225 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 6.693 | in | s= | 6.693 | in |
| db= | 0.630 | in | db= | 0.630 | in |
| fs,max= | 23.665 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 23.665 | **OUTSIDE FACE BAR SPACING O.K.** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

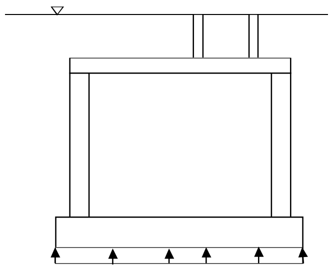
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## BUOYANCY CHECK (FLOTATION)

This loading condition checks for flotation.

Ground water height: 0.00 ft



**A.) Dead Load**

TOTAL DL: 251.62 kips

**B.) Bouyant Force**

TOTAL BOUYANT FORCE: 0.00 kips

**C). Safety Factor**

Safety Factor = DL / B 25162123.82 **> 1.25, OK**

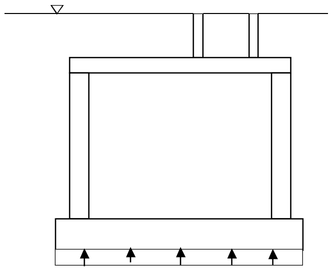
# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN BASE SLAB

| | | | | |
|---|---|---|---|---|
| DL1, ROOF SLAB: | 233.92 | cf conc = | 35.09 | kips |
| DL2, WALLS: | 402.59 | cf conc = | 60.39 | kips |
| DL6, SOIL ON FTG EXT - DRY: | 0.00 | cf soil = | 0.00 | kips |
| DL5, SOIL ON FTG EXT - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL8, SOIL ON TOP SLAB - DRY: | 1052.66 | cf soil = | 121.06 | kips |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips |
| TOTAL DL CONC: | | | 95.48 | kips |
| TOTAL DL SOIL: | | | 121.06 | kips |
| TOTAL DL: | | | 0.54 | ksf |
| TOTAL SOIL LOAD, EV: | | | 0.68 | ksf |
| TOTAL UNIFORM LIVE LOAD, LL: | | | 0.18 | ksf |
| HYDROSTATIC, B: | | | 0.00 | ksf |
| qunfact =DL + LL + EV + B | | | 1.39 | ksf |
| qfact = 1.2*DL + 1.75*LL + 1.3*EV +1.0*B PER AASHTO | | | 1.84 | ksf |
| qfact =1.2*DL + 1.6*LL + 1.6*EV +1.2*B PER ACI 318 | | | 2.02 | ksf |



**BEARING PRESSURE OK**

b/c = 1.30 SAY ====> 1.25

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | |
|---|---|
| -My | -45 |
| +My | 48 |
| -Mx | -45 |
| +Mx | 63 |
| Vside max | 0.36 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 3.14 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 12.23 | klf | <== Shear at side of wall is compression (Nu) in other side wall |

**B.) FLEXURE DESIGN LOADS - Short Dir. (Mx)**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 4.43 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -23.36 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 32.71 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Long Dir. (My)**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 4.43 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -23.36 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 24.92 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Base Slab:**

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov ($in^2$) |
|---|---|---|---|---|---|
| Short Direction, Inside | 20.00 | 0.4869 | 0.7874 | 7.87 | 0.74 |
| Long Dir, Inside | 20.00 | 0.4869 | 0.7874 | 7.87 | 0.74 |
| Short Direction, Outside | 16.00 | 0.3116 | 0.6299 | 7.87 | 0.47 |
| Long Dir, Outside | 16.00 | 0.3116 | 0.6299 | 7.87 | 0.47 |

| | | | | | |
|---|---|---|---|---|---|
| phiv = | 0.75 | | | | |
| Base Slab Thickness: | 1.31 | ft | | | |
| Cover (inside) = | 3.00 | in. | Cover (outside) = | 3.00 | in. |
| d (M+) short = | 12.35 | in. = f - cover - 1/2db(short) | d (M-) short = | 12.43 | in. = f - cover - 1/2db(short) |
| d (M+) long = | 11.57 | in. = f - cover - db(short) - 1/2db(long) | d (M-) long = | 11.80 | in. = f - cover - db(short) - 1/2db(long) |
| f'c = | 4.00 | ksi | dmin= | 11.57 | in. |
| bw = | 12.00 | (per linear ft of slab) | | | |

Check Shear in Base Slab

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 17.56 | kips |
| PHI*Vc = | 13.17 | kips |
| Vu = Cs*q*a = | 12.23 | **SHEAR CAPACITY O.K.** |

Check Moment Capacity (Mu (short)+ inside face reinf. ): Mx+

| | | | |
|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 |
| Asprov = | 0.74 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.09 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 39.43 | kip*ft | |
| Mu+ inside face reinf= | 32.71 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu (short)- outside face reinf.): Mx-

| | | | |
|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 |
| As = | 0.47 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.70 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 24.48 | kip*ft | |
| ABS Mu- ourside face= | 23.36 | **NEG MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu (long)+ inside face reinf. ): My+

| | | | |
|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 |
| Asprov = | 0.74 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.09 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 36.80 | kip*ft | |
| Mu+ inside face reinf= | 24.92 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu (long)- outside face reinf.): My-

| | | | |
|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 |
| As = | 0.47 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.70 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 25.82 | kip*ft | |
| ABS Mu- ourside face= | 23.36 | **NEG MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

| Unfactored Moment: | Load Case 1 |
|---|---|
| M+(short) unfactored= | 10.30 |
| M- (short) unfactored= | -7.35 |
| M+(long) unfactored= | 7.84 |
| M- (long) unfactored= | -7.35 |

| Crack Check (M(short)+ inside face reinf. ): M+x | | | Crack Check (Mu(short)- outside face reinf.): M-x | | |
|---|---|---|---|---|---|
| Asprov = | 0.74 | in2 | As = | 0.47 | in2 |
| d= | 12.35 | in | d= | 11.80 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.005 | | ρ= | 0.003 | |
| ρn= | 0.040 | | ρn= | 0.027 | |
| k= | 0.246 | | k= | 0.207 | |
| j= | 0.918 | | j= | 0.931 | |
| M+ unfactored= | 10.297 | kips.ft | M- unfactored= | 7.355 | kips.ft |
| fs= | 14.684 | ksi | fs= | 16.912 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 7.874 | in | s= | 7.874 | in |
| db= | 0.787 | in | db= | 0.630 | in |
| fs,max= | 20.900 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 21.085 | **OUTSIDE FACE BAR SPACING O.K.** |

| Crack Check (M(long)+ inside face reinf. ): M+y | | | Crack Check (Mu(long)- outside face reinf.): M-y | | |
|---|---|---|---|---|---|
| Asprov = | 0.74 | in2 | As = | 0.47 | in2 |
| d= | 11.57 | in | d= | 12.43 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.005 | | ρ= | 0.003 | |
| ρn= | 0.043 | | ρn= | 0.026 | |
| k= | 0.253 | | k= | 0.202 | |
| j= | 0.916 | | j= | 0.933 | |
| M+ unfactored= | 7.845 | kips.ft | M- unfactored= | 7.355 | kips.ft |
| fs= | 11.980 | ksi | fs= | 16.028 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 7.874 | in | s= | 7.874 | in |
| db= | 0.787 | in | db= | 0.630 | in |
| fs,max= | 20.900 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 21.085 | **OUTSIDE FACE BAR SPACING O.K.** |

# SEISMIC DESIGN LOAD

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**
- ACI 350-06 Code Requirements for Environmental Engineering Concrete Structures
- ACI 350.3-06 Seismic Design of Liquid-Containing Concrete Structures
- AASHTO LRFD Bridge Design Specifications 4th Edition, 2007
- ASCE 7-05

**Notes:**

## Seismic Design Load -- Parameters

**Liquid-Containing Concrete Structure**

GEOMETRY INFORMATION INPUT:

| | | | | |
|---|---|---|---|---|
| Outside length = | 15.09 | ft | 4600 | mm |
| Outside width = | 11.81 | ft | 3600 | mm |
| Inside Length L= | 13.12 | ft | 4000 | mm |
| Inside Width= | 9.84 | ft | 3000 | mm |
| design liquid depth HL= | 8.20 | ft | 2500 | mm |
| Exterior Wall thickness= | 0.98 | ft | 300 | mm |
| Interior Wall Thickness= | 0.00 | ft | 0 | mm |
| Roof slab thickness= | 1.31 | ft | 400 | mm |
| Floor slab thickness= | 1.31 | ft | 400 | mm |
| # of exterior walls= | 2 | | | |
| # of interior walls= | 0 | | | |
| # of end walls= | 2 | | | |
| design wall height Hw= | 8.20 | ft | 2500 | mm |
| Inside width transverse= | 9.84 | ft | 3000 | mm |

OTHER PARAMETERS:

| | | | |
|---|---|---|---|
| Concrete Weight= | | 0.15 | kcf |
| | I= | 1 | Table 4.1.1(a) |
| | Ri= | 3 | Table 4.1.1(b) |
| | Rc= | 1 | Table 4.1.1(b) |
| Liquid Weight= | | 0.0624 | kcf |
| | g= | 32.2 | ft/s^2 |
| | ρc= | 4.66 | lb-s^2/ft^4 |
| | ρL= | 1.94 | lb-s^2/ft^4 |
| | fc' = | 4000 | pci |
| | Ec= | 3,604,997 | psi |
| longi | $L/H_L$ = | 1.6 | |
| | 2Π/λ= | 0.65 | Figure 9.2.4 page 47 |
| trans | $L/H_L$ = | 1.2 | |
| | 2Π/λ= | 0.63 | Figure 9.2.4 page 47 |
| | Site Class: | D | |
| | $S_S$= | 1.5 | |
| | $S_1$= | 0.6 | |
| | $F_a$= | 1 | ASCE 7-05 (Table 11.4-1) |
| | $F_v$= | 1.92 | ASCE 7-05 (Table 11.4-2) |

## SEISMIC DESIGN LOAD

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### Seismic Design Load -- Step One and Step Two

DESIGN IS BASED ON ACI350.3-06 CHAPTER 4 - EARTHQUAKE DESIGN LOADS

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Longitudinal direction: | | | | | Transverse direction | | | |
| Step One | | | | | | | | | | |
| | | | Wr= | 35.09 | Kips | | | | | |
| | | | Ww= | 60.39 | Kips | | | | | |
| | | | L/HL= | 1.60 | | | | L/HL= | 1.20 | |
| | | | ε= | 0.75 | | Equation (9-44) | | ε= | 0.81 | Equation (9-44) |
| | | | εWw= | 45.56 | Kips | | | εWw= | 49.14 Kips | |
| | | We= | εWw+Wr= | 80.64 | Kips | | We= | εWw+Wr= | 84.23 Kips | |
| Step Two | | | | | | | | | | |
| | total mass of liquid | | WL= | 66.11 | Kips | | | | | |
| | | | Wi/WL= | 0.64 | | Equation (9-1) | | Wi/WL= | 0.75 | Equation (9-1) |
| | | | Wi= | 42.09 | Kips | | | Wi= | 49.47 Kips | |
| | | | Wc/WL= | 0.41 | | Equation (9-2) | | Wc/WL= | 0.31 | Equation (9-2) |
| | | | Wc= | 26.87 | Kips | | | Wc= | 20.73 Kips | |

## SEISMIC DESIGN LOAD

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### Seismic Design Load -- Step Three and Step Ten

Step 3 to 9

| | Longitudinal direction: | Exterior walls | | | Transverse direction | Exterior walls | | |
|---|---|---|---|---|---|---|---|---|
| mw= | 37.61 | lb-s^2/ft^4 | | mw= | 37.61 | lb-s^2/ft^4 | |
| mi= | 66.40 | lb-s^2/ft^4 | | mi= | 58.53 | lb-s^2/ft^4 | |
| hw= | 4.10 | ft | | hw= | 4.10 | ft | |
| hi/HL= | 0.38 | | | hi/HL= | 0.39 | | |
| hi= | 3.08 | ft | | hi= | 3.18 | ft | |
| h= | 3.45 | ft | | h= | 3.54 | ft | |
| k= | 3022710.90 | lb/ft^2 | | k= | 2791154.62 | lb/ft^2 | |
| m= | 104.01 | lb-s^2/ft^4 | Equation (9-10) | m= | 96.14 | lb-s^2/ft^4 | Equation (9-10) |
| Ti= | 0.04 | s | | Ti= | 0.04 | s | |
| Tc= | 2.35 | s | Equation (9-14) | Tc= | 1.98 | s | Equation (9-14) |
| Ts= | 0.77 | s | Equation (9-34) | Ts= | 0.77 | s | Equation (9-34) |
| $S_{DS}$= | 1.00 | | Equation (9-35) | $S_{DS}$= | 1.00 | | Equation (9-35) |
| $S_{D1}$= | 0.77 | | Equation (9-36) | $S_{D1}$= | 0.77 | | Equation (9-36) |
| Ci= | 1.00 | s | Equation (9-32/9-33) | Ci= | 1.00 | s | Equation (9-32/9-33) |
| Cc= | 0.43 | s | Equation (9-37/9-38) | Cc= | 0.58 | s | Equation (9-37/9-38) |

Step 10

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| CiI= | 1.00 | | | CiI= | 1.00 | | |
| CcI= | 0.43 | | | CcI= | 0.58 | | |
| Pw= | 15.19 | kips | Equation (4-1) | Pw= | 16.38 | kips | Equation (4-1) |
| Pr= | 11.70 | kips | Equation (4-2) | Pr= | 11.70 | kips | Equation (4-2) |
| Pi= | 14.03 | kips | Equation (4-3) | Pi= | 16.49 | kips | Equation (4-3) |
| Pc= | 11.63 | kips | Equation (4-4) | Pc= | 12.08 | kips | Equation (4-4) |
| V= | 42.53 | kips | Equation (4-5) | V= | 46.17 | kips | Equation (4-5) |
| hc/HL= | 0.62 | | Equation (9-5) | hc/HL= | 0.67 | | Equation (9-5) |
| hc= | 5.06 | | | hc= | 5.50 | | |

Simplified method: Considering Uniform distribution of shear force:

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Unit base shear | v= | 1.80 | klf | Unit base shear | v= | 1.53 | klf |
| | q= | 219.52 | psf | | q= | 186.51 | psf |

## SEISMIC DESIGN LOAD

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### Seismic Design Load + Seismic-Induced Earth Pressure

| | | | |
|---|---|---|---|
| Seismic Design Load: | q= | 219.52 | psf |
| Seismic-Induced Earth Pressure: | qoe= | 1152.97 | psf |
| Total Seismic Lateral Load: | qe= | 1372.49 | psf |

# SEISMIC-INDUCED EARTH PRESSURE

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**
ACI 350-06 Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3-06 Seismic Design of Liquid-Containing Concrete Structures
AASHTO LRFD Bridge Design Specifications 4th Edition, 2007

**Notes:**

## PARAMETERS FOR EARTHQUAKE-INDUCED EARTH PRESSURE

CALCULATION OF EARTHQUAKE-INDUCED EARTH PRESSURE:

(REF: ASSHTO 2007 - Appendix A11.1.1.1)

MONONOBE-OKABE ANALYSIS

| | | | | | |
|---|---|---|---|---|---|
| Unit weight of soil: | GAMMA = | 115.00 | Lbs/CF | | |
| | t= | 1.31 | feet | | |
| | h= | 5.91 | Feet | | |
| | a = | 8.20 | Feet | | |
| Angle of friction of soil: | PHI = | 30.00 | Degrees: | RAD= | 0.52359878 |
| | THETA = | 16.70 | Degrees: | RAD= | 0.29145679 |
| Angle of friction soil/tank: | DELTA = | 26.00 | Degrees: | RAD= | 0.45378561 |
| Ground acceleration | A = | 0.60 | g | | |
| Horizontal acceleration coef. | kh = | 0.300 | | | |
| Backfill slope angle: | i = | 0.00 | Degrees: | RAD= | 0 |
| Slope of soil face: | BETA = | 0.00 | Degrees: | RAD= | 0 |

## SEISMIC-INDUCED EARTH PRESSURE

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 3000mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### EARTHQUAKE-INDUCED EARTH PRESSURE

SEISMIC ACTIVE EARTH PRESSURE:

$\psi$ = 2.278

Kae = 0.591 Equation (A11.1.1.1-2)

SEISMIC AT-REST EARTH PRESSURE (AASHTO Pg C-87)

Koe = 0.886

SEISMIC FORCE:

Eoe = 9456.774 lb Equation (A11.1.1.1-1)

qoe= 1152.97 plf

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**

AASHTO LRFD Bridge Design Specifications 4th Edition, 2007
ACI 318-08
ACI 350-06

**Notes:**

**Since cover is more than 2 feet, H20 wheel load is considered as uniformly distributed.**

## General

1. AT REST EARTH PRESSURE IS ASSUMED.
2. THE MONONOBE-OKABE APPROACH IS USED TO GET THE LATERAL EARTH PRESSURE CAUSED BY EARTHQUAKE
3. SANITARY COEFFICIENTS ARE INCLUDED IN DESIGN
4. CONSIDER WALL HINGED TOP AND BOTTOM
5. SEISMIC COEFFICIENTS: Ss=1.50g AND S1= 0.60g.
6. ASSUME GROUND WATER ELEVATION IS 5.0M BELOW GRADE U.N.O. DUE TO SITE SPECIFIC TESTS
7. DESIGN LOAD ON ROOF SLAB: AASHTO H20 PER AASHTO SPECIFICATION
8. LIVE LOAD IMPACT WILL NOT BE INCLUDED
9. ROOF SLAB: HINGED FOUR SIDES
10. TWO FEET LIVE LOAD SURCHARGE ON THE TANK WALLS.
11. CORROSION RESISTANT CONCRETE OR CEMENT SHOULD BE USED, TYPE II CEMENT
12. BOTTOM SLAB: HINGED FOUR SIDES
13. PER ACI 350 - SECTION 7.12.2.2, MINIMUM FLEXURE REINFORCEMENT IS 13MM AND NOT MORE THAN 300MM APART.
14.THE SAFETY FACTOR FOR FLOTATION IS 1.25; ACI 350.4R-04 SECTION 3.1.2
15. LOAD COMBINATION PER AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS 4TH EDITION
16. TIRE CONTACT AREA IS 10 INCHES x 20 INCHES: AASHTO 3.6.1.2.5

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

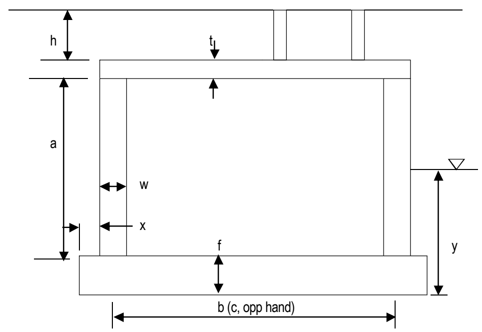
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Geometry

GEOMETRY INFORMATION INPUT:

| | | | | |
|---|---|---|---|---|
| WALL HEIGHT, a: | 8.20 | ft | 2500 | mm |
| LONG WALL LENGTH, b: | 14.11 | ft | 4300 | mm |
| R.S. AND F.S. SPAN =SHORT WALL LENGTH, c: | 5.91 | ft | 1800 | mm |
| WALL THICKNESS, w: | 0.98 | ft | 300 | mm |
| TOP SLAB THICKNESS, t: | 1.31 | ft | 400 | mm |
| BOT SLAB THICKNESS, f: | 1.31 | ft | 400 | mm |
| DEPTH OF FILL ABOVE ROOF SLAB, h: | 5.91 | ft | 1800 | mm |
| HEIGHT OF WATER ABOVE BASE, y: | 0.00 | ft | 0 | mm |
| LENGTH OF FTG EXTENSION, x: | 0.00 | ft | 0 | mm |



# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Additional Input Parameters

GEOTECHNICAL INFORMATION:

| | | | | |
|---|---|---|---|---|
| WEIGHT OF SOIL BACKFILL (Dry), gsoil: | 115.00 | Lbs/CF | | |
| WEIGHT OF SOIL BACKFILL (Saturated): | 135.00 | Lbs/CF | | |
| ALLOWABLE BEARING CAPACITY: | 2.00 | ksf | | |
| PHI: FRICTION ANGLE OF BACKFILL: | 20.90 | DEG | RAD = | 0.3648 |
| AT REST PRESSURE COEFF, Ko | 0.50 | | | |
| ACTIVE PRESSURE COEFF, Ka: | 0.30 | | | |
| LIVE LOAD SURCHARGE CONSIDERED: | YES | | | |

| WALL LOADING CONDITION TWO | | | WALL LOADING CONDITION ONE | | |
|---|---|---|---|---|---|
| HEIGHT SOIL ABOVE BOT SLAB EXT - WET: | 0.00 | ft | HEIGHT SOIL ABOVE BOT SLAB EXT - WET: | 0.00 | ft |
| HEIGHT SOIL ABOVE BOT SLAB EXT - DRY: | 0.00 | ft | HEIGHT SOIL ABOVE BOT SLAB EXT - DRY: | 15.42 | ft |
| HEIGHT SOIL ON TOP SLAB - WET: | 0.00 | ft | HEIGHT SOIL ON TOP SLAB - WET: | 0.00 | ft |
| HEIGHT SOIL ON TOP SLAB - DRY: | 5.91 | ft | HEIGHT SOIL ON TOP SLAB - DRY: | 5.91 | ft |

MATERIAL PROPERTIES:

| | | |
|---|---|---|
| CUBIC WEIGHT CONCRETE=wconc: | 150.00 | Lbs/CF |
| COMP. STRENGTH OF CONC. = F'c: | 4.00 | ksi |
| TENSILE STRENGTH OF REBAR = Fy: | 60.00 | ksi |
| WEIGHT OF WATER = ww: | 62.40 | Lbs/CF |

Design Strength Factors - Environmental Durability Factor (ACI 350-06 R9.2.6)

| | |
|---|---|
| ϕ , Flexure: | 0.90 |
| ϕ , Shear: | 0.75 |

| | | WALL CASE 1 | | WALL CASE 2 | | WALL CASE 3** | | |
|---|---|---|---|---|---|---|---|---|
| Environmental Durability Factor (ACI 350-06 EQ 9-8): | ROOF SLAB | Top | Bottom | Top | Bottom | Top | Bottom | BASE SLAB |
| FLEXURE: | 2.06 | 1.99 | 1.57 | 1.99 | 1.99 | n/a | n/a | 2.21 |
| SHEAR: | 1.46 | 1.41 | 1.11 | 1.41 | 1.41 | n/a | n/a | 1.56 |

ENVIRONMENTAL EXPOSURE: SEVERE

**Note: No Sd for Seismic load combinations ACI 350 Section 21.2.1.8

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Dead Load

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| DL1, ROOF SLAB: | 136.46 | cf conc = | 20.47 | kips | | | |
| DL2, WALLS: | 323.13 | cf conc = | 48.47 | kips | | | |
| DL3, BOTTOM SLAB: | 136.46 | cf conc = | 20.47 | kips | | | |
| | | | | | TOTAL CONCRETE QUANTITY: | 22.08 | cy |
| DL5, SOIL ON FTG EXT - WET: | 0.00 | cf soil = | 0.00 | kips | | | |
| DL6, SOIL ON FTG EXT - DRY: | 0.00 | cf soil = | 0.00 | kips | | | |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips | TOTAL SOIL QUANTITY: | 22.74 | cy |
| DL8, SOIL ON TOP SLAB - DRY: | 614.05 | cf soil = | 70.62 | kips | (only above plan limits of base slab) | | |
| TOTAL DL CONC: | | | 89.41 | kips | | | |
| TOTAL DL SOIL: | | | 70.62 | kips | | | |
| TOTAL DL: | | | 160.02 | kips | | | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN ROOF SLAB

**Design Uniform Load:**

| | | | | |
|---|---|---|---|---|
| DL1, ROOF SLAB: | 136.46 | cf conc = | 20.47 | kips |
| TOTAL UNIFORM DL: | | | 0.20 | ksf |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL8, SOIL ON TOP SLAB - DRY: | 614.05 | cf soil = | 70.62 | kips |
| TOTAL SL: | | | 70.62 | kips |
| TOTAL UNIFORM SL: | | | 0.68 | ksf |
| Ratio b/c = | 2.39 | | | |
| TWO WAY SLAB | NO, Use one way slab for top slab design | | **SEE AASHTO 4.6.2.1.5** | *****CHECK fs_max values below…not setup for one-way slab***** |

Per AASHTO 12.11.2.1, when the depth of fill is less than 2 ft, the wheel load shall be distributed as in slabs with concentrated loads (4.6.2.10). And also based on the distribution of the wheel load through earth fill

| | | | | |
|---|---|---|---|---|
| DEPTH OF FILL, h: | 5.91 | ft | **SINCE THE COVER OVER THE TOP SLAB IS GREATER THAN 2 FT, THE LIVE LOAD IS DISTRIBUTED IN ACCORDANCE WITH AASHTO 4.6.2.10.** | |
| DISTRIBUTE CONCENTRATED LOAD? | NO | | | |
| INCLUDE LL IMPACT (AASHTO 3.6.2.1)? | NO | | . | |
| LIVE LOAD IMPACT (AASHTO 3.6.2.2): | 1.00 | | | |
| # WHEELS ALONG LENGTH: | 1.00 | | | |
| # WHEELS ON ALONG WIDTH: | 2.00 | | | |
| HI-93 WHEEL LOAD | 16.00 | kips | | |
| DISTRIBUTION WDITH, SHORT SIDE, d1: | 5.91 | ft | <=== Quick check, this dist should be less than | 22.34 ft, which would be dist length if areas don't overlap |
| DISTRIBUTION WDITH, LONG SIDE, d2: | 12.00 | ft | <=== Quick check, this dist should be less than | 12.00 ft, which would be dist length if areas don't overlap |
| TOTAL UNIFORM LIVE LOAD, wl: | 0.45 | ksf | | |
| TOTAL LIVE LOAD: | 32.00 | kips | | |

**AASHTO 3.24.6.1 -- Slab supported on four sides**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| For concentrated load at center: | p = | 1.00 | of Total Load | For concentrated load at center: | p = | 0.00 | of Total Load |
| For Uniformly distributed load: | p = | 1.00 | of Total Load | For Uniformly distributed load: | p = | 0.00 | of Total Load |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Roof Slab:**

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov ($in^2$) |
|---|---|---|---|---|---|
| Short Direction, Bottom | 25.00 | 0.7609 | 0.9843 | 5.12 | 1.78 |
| Long Dir, Bottom | 20.00 | 0.4869 | 0.7874 | 5.12 | 1.14 |

**Verify long rebar meets AASHTO 5.14.4**

| | | | |
|---|---|---|---|
| % Distribution Steel = | 41.15 | % | |
| As long required = | 0.73 | $in^2$ | |
| As long provided = | 1.14 | $in^2$ | **OK** |

**First, consider steel in short direction.**

Positive moment - Center - (Rebar at Bottom of Slab)

| | | |
|---|---|---|
| qunfact = DL + LL + SL | 1327.49 | psf |
| qfact =(1.2DL+1.6LL+1.6SL) | 2045.24 | psf |
| $S_d$: | 2.06 | |
| M+Coeff: | 0.125 | |
| M+=MCoeff*q*c$^2$/1000*$S_d$: | 18.38 | ft*kips |
| Top Slab Thickness: | 1.31 | ft |
| Cover = | 2.00 | in. |
| d (M+) short = | 13.26 | in. = t - cover - 1/2db(short) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of slab) |

Check Moment Capacity (M+):

| | | | |
|---|---|---|---|
| As T & S= | 0.34 | in2 | =0.0018bh |
| Asprov = | 1.78 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 2.62 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 95.89 | kip*ft | |
| M+ = | 18.38 | **POS MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Roof Slab Cont.:**

**Next, consider steel in long direction.**

Positive moment - Center - (Rebar at Bottom of Slab)

| | | | |
|---|---|---|---|
| qunfact = DL + LL + SL | 1327.49 | psf | |
| qfact =(1.2DL+1.6LL+1.6SL) | 2045.24 | psf | |
| $S_d$: | 2.06 | | |
| M+Coeff: | 0.125 | | |
| M+=MCoeff*q*c$^2$/1000*$S_d$: | 0.00 | ft*kips | **Since one way slab design is used there is no moment considered in the long direction** |
| d (M+) long = | 12.37 | in. = t - cover - db(short) - 1/2db(long) | |
| f'c = | 4.00 | ksi | |
| bw = | 12.00 | (per linear ft of slab) | |

Check Moment Capacity (M+):

| | | | |
|---|---|---|---|
| As T & S= | 0.34 | in2 | =0.0018bh |
| Asprov = | 1.14 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.68 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 59.23 | kip*ft | |
| M+ = | 0.00 | **POS MOMENT CAPACITY O.K.** | |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

Unfactored Moment:

| | | | | | |
|---|---|---|---|---|---|
| qunfact =(DL+LL+SL) | 1.33 | ksf | qunfact =(DL+LL+SL) | 1.33 | ksf |
| M+ unfactored= | 5.79 | ft*kips | M+ unfactored= | 0.00 | ft*kips |

| Crack Check (M+ bottom face short reinf.): | | | Crack Check (M+ bottom face long reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 1.78 | in2 | Asprov = | 1.14 | in2 |
| d= | 13.26 | in | d= | 12.37 | in |
| n= | 8.04 | | n= | 8.04 | |
| ρ= | 0.011 | | ρ= | 0.008 | |
| ρn= | 0.090 | | ρn= | 0.062 | |
| k= | 0.344 | | k= | 0.295 | |
| j= | 0.885 | | j= | 0.902 | |
| M+ unfactored= | 5.787 | kips.ft | M+ unfactored= | 0.000 | kips.ft |
| fs= | 3.317 | ksi | fs= | 0.000 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 5.118 | in | s= | 5.118 | in |
| db= | 0.984 | in | db= | 0.787 | in |
| fs,max= | 26.958 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 27.481 | **INSIDE FACE BAR SPACING O.K.** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Check Shear Capacity of Top Slab**

| | | |
|---|---|---|
| qunfact = DL + LL + SL | 1.33 | ksf |
| qfact =(1.2DL+1.6LL+1.6SL) | 2.05 | ksf |
| $S_d$: | 1.46 | |
| Csmax = | 0.50 | |
| phiv = | 0.75 | |
| d = | 13.26 | in. = t - cover - 1/2db(short) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of wall) |

Check Shear in Roof Slab

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 20.12 | kips |
| PHI*Vc = | 15.09 | kips |
| Vu = Cs*q*c*$S_d$ | 8.82 | **SHEAR CAPACITY O.K.** |

Shear Friction

| | | | |
|---|---|---|---|
| u: | 1.000 | | 11.6.4.3 |
| phiv: | 0.75 | | |
| Avf (req'd)=Vu/(Fy*u*phi): | 0.20 | $in^2$ | |
| As (provided): | 1.78 | $in^2$ | **OK** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN WALLS

| | | |
|---|---|---|
| ww = | 62.40 | pcf |
| Wall clear height a = | 8.20 | ft |
| Wall thickness, w= | 11.81 | in |
| Bottom slab thickness f = | 1.31 | ft |
| qw = ww*a | 511.81 | psf |

Use at rest Soil pressure Ko

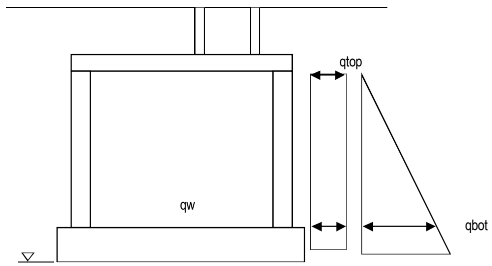
# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 1 - Tank is full and Water Table below the invert of the structure - Lateral Earth Pressure + 2ft LL Surcharge

| | | | | | |
|---|---|---|---|---|---|
| ww = | 62.40 | pcf | Soil pressure | | |
| Wall clear height a = | 8.20 | ft | qsoil top = | 530.03 | psf |
| Wall thickness, w= | 11.81 | in | qsoil bot = | 1001.65 | psf |
| qwtop = ww*a | 0.00 | psf | | | |
| qwbot= ww*a | 511.81 | psf | | | |
| qtop_unfact = | 530.03 | psf | | | |
| qbot_unfact = | 489.84 | psf | | | |
| qtop_fact: 1.6*qsoiltop + 1.2*qwtop = | 848.04 | psf | | | |
| qbot_fact: 1.6*qsoilbot + 1.2*qwbot = | 988.46 | psf | | | |




| Environmental Durability Factor, Sd: | Flexure | Shear |
|---|---|---|
| Sd_top = | 1.99 | 1.41 |
| Sd_bot = | 1.57 | 1.11 |

| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 0.72 | SAY ====> | 0.75 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -26 |
| +My | 53 | 38 |
| -Mx | -51 | -26 |
| +Mx | 91 | 27 |
| Vside max | 0.37 | 0.3 |
| Vbot | 0.45 | 0.27 |
| Vtop | 0.45 | 0.27 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_d$ = | 0.75 | ksf | |
| | qbotfact * $S_d$ = | 0.55 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 1.96 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 2.38 | klf | <== Shear at top of wall is tensile force (Nu) in roof slab |
| | Vubot = | 2.38 | klf | <== Shear at bottom of wall is tensile force or compression force (Nu) in base slab |

Tension reinforcement requirement for floor slab and roof slab:

| | | | | |
|---|---|---|---|---|
| | Tubot = | 2.38 | klf | |
| | Tutop = | 2.38 | klf | |
| | phiT= | 0.90 | | |
| Bot slab | Ast =Tu/(Fy*phiT): | 0.044 | in^2/ft | **Main Reinforcement Direction** |
| Top slab | Ast =Tu/(Fy*phiT): | 0.044 | in^2/ft | **Main Reinforcement Direction** |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_d$ = | 1.05 | ksf | |
| | qbotfact * $S_d$ = | 0.77 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -3.13 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 5.58 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -3.13 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 3.25 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

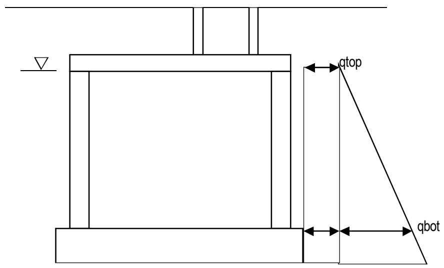
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 2 - Tank is empty and water table at its highest elevation - Lateral Earth Pressure + 2ft LL Surcharge

| | qtop | | qbot | |
|---|---|---|---|---|
| Surcharge = | 115.00 | psf | 115.00 | psf |
| Soil = | 415.03 | psf | 886.65 | psf |
| Wet Soil = | 0.00 | psf | 0.00 | psf |
| Water = | 0.00 | psf | 0.00 | psf |

| | | |
|---|---|---|
| qtop_unfact = | 530.03 | psf |
| qbot_unfact = | 1001.65 | psf |
| qtop_fact: 1.6*qtop_unfact = | 848.04 | psf |
| qbot_fact: 1.6*qbot_unfact = | 1602.64 | psf |




| Environmental Durability Factor, Sd: | Flexure | Shear |
|---|---|---|
| Sd_top = | 1.99 | 1.41 |
| Sd_bot = | 1.99 | 1.41 |

| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 0.72 | SAY ====> | 0.75 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -26 |
| +My | 53 | 38 |
| -Mx | -51 | -26 |
| +Mx | 91 | 27 |
| Vside max | 0.37 | 0.3 |
| Vbot | 0.45 | 0.27 |
| Vtop | 0.45 | 0.27 |

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 5 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -30 | -17 |
| +My | 30 | 20 |
| -Mx | -30 | -17 |
| +Mx | 48 | 18 |
| Vside max | 0.2 | 0.18 |
| Vbot | 0.31 | 0.21 |
| Vtop | 0.14 | 0.06 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_{d=}$ | 1.19 | ksf | |
| | qbotfact * $S_{d=}$ | 2.25 | ksf | |
| | qtopfact - qbotfact = | 1.06 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 5.36 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 5.62 | klf | <== Shear at top of wall is compressiom (Nu) in roof slab |
| | Vubot = | 7.10 | klf | <== Shear at bottom of wall is compressiom (Nu) in base slab |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact * $S_{d=}$ | 1.68 | ksf | |
| | qbotfact * $S_{d=}$ | 3.18 | ksf | |
| | qtopfact - qbotfact = | 1.50 | | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.80 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 15.14 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.80 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 9.03 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

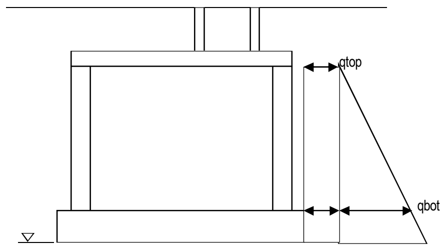
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## WALL DESIGN: LOAD CASE 3 - Under Seismic Loads + 2ft LL Surcharge

| | | |
|---|---|---|
| qltop = | 115.00 | psf |
| qlbot = | 115.00 | psf |
| qetop = | 1388.92 | psf |
| qebot = | 1388.92 | psf |
| qtop_unfact = | 1503.92 | psf |
| qbot_unfact = | 1503.92 | psf |
| qtop_fact: 1.6*qltop + 1.0*qetop = | 1572.92 | psf |
| qbot_fact: 1.6*qlbot + 1.0*qebot = | 1572.92 | psf |

| | | | |
|---|---|---|---|
| b/a = | 1.72 | SAY ====> | 1.75 |
| c/a = | 0.72 | SAY ====> | 0.75 |




**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | b/a | c/a |
|---|---|---|
| -My | -51 | -26 |
| +My | 53 | 38 |
| -Mx | -51 | -26 |
| +Mx | 91 | 27 |
| Vside max | 0.37 | 0.3 |
| Vbot | 0.45 | 0.27 |
| Vtop | 0.45 | 0.27 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qtopfact = | 1.57 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | qbotfact = | 1.57 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside = | 4.77 | klf | <== Shear at side of wall is compression (Nu) in other side wall |
| | Vutop = | 5.81 | klf | <== Shear at top of wall is compressiom (Nu) in roof slab |
| | Vubot = | 5.81 | klf | <== Shear at bottom of wall is compressiom (Nu) in base slab |

**B.) FLEXURE DESIGN LOADS - Vertical Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | qtopfact = | 1.57 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | qbotfact = | 1.57 | ksf | <--- No Sd for Seismic load combinations ACI 350 Section 21.2.1.8 |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -5.40 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 9.63 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Horizontal Reinforcement (MAIN REINFORCEMENT)**

| | | | | |
|---|---|---|---|---|
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -5.40 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 5.61 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN WALL REINFORCEMENT

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov ($in^2$) |
|---|---|---|---|---|---|
| Wall - Vertical (outside) | 16.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Horiz (outside) | 16.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Vertical (inside) | 16.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |
| Wall - Horiz (inside) | 16.00 | 0.3116 | 0.6299 | 6.69 | 0.56 |

**Check Shear Capacity:**

| DESIGN LOADS | Load Case 1 | Load Case 2 | Load Case 3 | Max (kips) |
|---|---|---|---|---|
| Vubot, total: | 2.38 | 7.10 | 5.81 | 7.10 |
| Vutop, total: | 2.38 | 5.62 | 5.81 | 5.81 |
| Vuside, total: | 1.96 | 5.36 | 4.77 | 5.36 |

| | | |
|---|---|---|
| phiv = | 0.75 | |
| Wall Thickness, w: | 0.98 | ft |
| Cover = | 2.00 | in. |
| d (M+) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of wall) |

d (M+) horiz = 8.87 in. = w - cover - db(vert) - 1/2db(horiz)

Check Shear in Tank Wall - top/bot

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 14.41 | kips |
| PHI*Vc = | 10.81 | kips |
| Vubot = | 7.10 | **SHEAR CAPACITY O.K.** |

Check Shear in Tank Wall - side

| | | |
|---|---|---|
| Vc = 2*(1)*f'c^.5*bw*d | 13.46 | kips |
| PHI*Vc = | 10.09 | kips |
| Vubot = | 5.36 | **SHEAR CAPACITY O.K.** |

Shear Friction

| | | | |
|---|---|---|---|
| u: | 1.000 | | 11.6.4.3 |
| phiv: | 0.75 | | |
| Avf (req'd)=Vu/(Fy*u*phi): | 0.16 | $in^2$ | |
| As (provided): | 0.56 | $in^2$ | **OK** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Check Flexural Capacity:**

| Steel | DESIGN LOADS | Load Case 1 | Load Case 2 | Load Case 3 |
|---|---|---|---|---|
| Vertical | Mu+ inside face reinf. | 5.58 | 15.14 | 9.63 |
| | Mu- outside face reinf. | -3.13 | -8.80 | -5.40 |
| Horizontal | Mu+ inside face reinf. | 3.25 | 9.03 | 5.61 |
| | Mu- outside face reinf. | -3.13 | -8.80 | -5.40 |

| Max (k*ft) | Max (kip*in) |
|---|---|
| 15.14 | 181.74 |
| -8.80 | -105.60 |
| 9.03 | 108.32 |
| -8.80 | -105.60 |

**Design for Vertical Bending Moments (determine Vertical Steel):**

| | | |
|---|---|---|
| Wall Thickness, w: | 0.98 | ft |
| Cover (inside) = | 2.00 | in. |
| d (M+) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| d (M+) horiz = | 8.87 | in. = w - cover - db(vert) - 1/2db(horiz) |
| f'c = | 4.00 | ksi |
| bw = | 12.00 | (per linear ft of slab) |

| | | |
|---|---|---|
| Cover (outside) = | 2.00 | in. |
| d (M-) vert = | 9.50 | in. = w - cover - 1/2db(vert) |
| d (M-) horiz = | 8.87 | in. = w - cover - db(vert) - 1/2db(horiz) |

Check Moment Capacity (Mu+ inside face reinf. ):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| Asprov = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 22.84 | kip*ft | |
| Mu+ inside face reinf= | 15.14 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu- outside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| As = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 22.84 | kip*ft | |
| ABS Mu- ourside face= | 8.80 | **NEG MOMENT CAPACITY O.K.** | |

**Next, consider steel in horizontal direction.**

Check Moment Capacity (Mu+ inside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| Asprov = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phif = | 0.90 | | |
| PHI*Mn = | 21.26 | kip*ft | |
| Mu+ inside face reinf= | 9.03 | **POS MOMENT CAPACITY O.K.** | |

Check Moment Capacity (Mu- outside face reinf.):

| | | | |
|---|---|---|---|
| As T & S= | 0.21 | in2 | =0.0030bh/2 |
| As = | 0.56 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 0.82 | in | |
| phi = | 0.90 | | |
| PHI*Mn = | 21.26 | kip*ft | |
| ABS Mu- ourside face= | 8.80 | **NEG MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

| Unfactored Moment: | Load Case 1 | Load Case 2 | Load Case 3 |
|---|---|---|---|
| M+ vert unfactored= | 1.65 | 4.49 | 9.21 |
| M- vert unfactored= | -0.93 | -2.61 | -5.16 |
| M+ horiz unfactored= | 0.96 | 2.67 | 5.36 |
| M- horiz unfactored= | -0.93 | -2.61 | -5.16 |

| Crack Check (M+ inside face vertical reinf.): | | | Crack Check (Mu- outside face vertical reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 0.56 | in2 | As = | 0.56 | in2 |
| d= | 9.50 | in | d= | 9.50 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.015 | | ρ= | 0.015 | |
| ρn= | 0.118 | | ρn= | 0.118 | |
| k= | 0.382 | | k= | 0.382 | |
| j= | 0.873 | | j= | 0.873 | |
| M+ unfactored= | 9.207 | kips.ft | M- unfactored= | 5.160 | kips.ft |
| fs= | 23.867 | ksi | fs= | 13.376 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 6.693 | in | s= | 6.693 | in |
| db= | 0.630 | in | db= | 0.630 | in |
| fs,max= | 23.665 | ****N.G. - REDUCE INSIDE FACE BAR SPACING****** | fs,max= | 23.665 | **OUTSIDE FACE BAR SPACING O.K.** |
| | | **OK PER INSPECTION** | | | |

| Crack Check (M+ inside face horiz reinf.): | | | Crack Check (Mu- outside face horiz reinf.): | | |
|---|---|---|---|---|---|
| Asprov = | 0.56 | in2 | As = | 0.56 | in2 |
| d= | 8.87 | in | d= | 8.87 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.016 | | ρ= | 0.016 | |
| ρn= | 0.127 | | ρn= | 0.127 | |
| k= | 0.392 | | k= | 0.392 | |
| j= | 0.869 | | j= | 0.869 | |
| M+ unfactored= | 5.362 | kips.ft | M- unfactored= | 5.160 | kips.ft |
| fs= | 14.946 | ksi | fs= | 14.382 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 6.693 | in | s= | 6.693 | in |
| db= | 0.630 | in | db= | 0.630 | in |
| fs,max= | 23.665 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 23.665 | **OUTSIDE FACE BAR SPACING O.K.** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

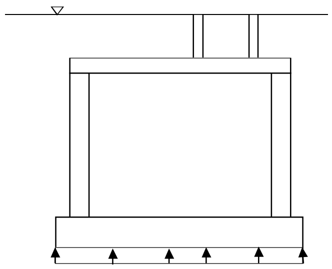
## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## BUOYANCY CHECK (FLOTATION)

This loading condition checks for flotation.

Ground water height: 0.00 ft



**A.) Dead Load**

TOTAL DL: 160.02 kips

**B.) Bouyant Force**

TOTAL BOUYANT FORCE: 0.00 kips

**C). Safety Factor**

Safety Factor = DL / B 16002205.56 **> 1.25, OK**

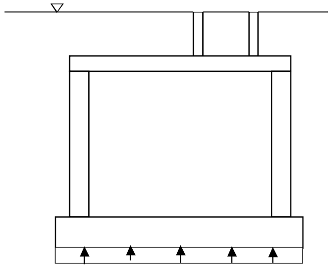
# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## DESIGN BASE SLAB

| | | | | |
|---|---|---|---|---|
| DL1, ROOF SLAB: | 136.46 | cf conc = | 20.47 | kips |
| DL2, WALLS: | 323.13 | cf conc = | 48.47 | kips |
| DL6, SOIL ON FTG EXT - DRY: | 0.00 | cf soil = | 0.00 | kips |
| DL5, SOIL ON FTG EXT - WET: | 0.00 | cf soil = | 0.00 | kips |
| DL8, SOIL ON TOP SLAB - DRY: | 614.05 | cf soil = | 70.62 | kips |
| DL7, SOIL ON TOP SLAB - WET: | 0.00 | cf soil = | 0.00 | kips |
| TOTAL DL CONC: | | | 68.94 | kips |
| TOTAL DL SOIL: | | | 70.62 | kips |
| TOTAL DL: | | | 0.66 | ksf |
| TOTAL SOIL LOAD, EV: | | | 0.68 | ksf |
| TOTAL UNIFORM LIVE LOAD, LL: | | | 0.31 | ksf |
| HYDROSTATIC, B: | | | 0.00 | ksf |
| qunfact =DL + LL + EV + B | | | 1.65 | ksf |
| qfact = 1.2*DL + 1.75*LL + 1.3*EV +1.0*B PER AASHTO | | | 2.22 | ksf |
| qfact =1.2*DL + 1.6*LL + 1.6*EV +1.2*B PER ACI 318 | | | 2.37 | ksf |



**BEARING PRESSURE OK**

b/c = 2.39 SAY ====> 1.25

**Input PCA Rectangular Concrete Tanks coefficients**

**Plate Analysis - Case:** 10 <---- HINGED TOP, HINGED BOTTOM, HINGED SIDES

| | |
|---|---|
| -My | -45 |
| +My | 48 |
| -Mx | -45 |
| +Mx | 63 |
| Vside max | 0.36 |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**A.) SHEAR DESIGN LOADS**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 3.71 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| | Vuside= | 7.89 | klf | <== Shear at side of wall is compression (Nu) in other side wall |

**B.) FLEXURE DESIGN LOADS - Short Dir. (Mx)**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 5.24 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.22 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 11.51 | k.ft/ft | **Inside Face Reinforcement** |

**C.) FLEXURE DESIGN LOADS - Long Dir. (My)**

| | | | | |
|---|---|---|---|---|
| | qfact * $S_d$ = | 5.24 | ksf | |
| | bw = | 12.00 | (per linear ft of wall) | |
| **Negative moment** | Muneg = | -8.22 | k.ft/ft | **Outside Face Reinforcement** |
| **Positive moment** | Mupos = | 8.77 | k.ft/ft | **Inside Face Reinforcement** |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Design Flexural Reinforcement in the Base Slab:**

| | Bar Dia. (mm) | As bar (in) | db (in) | Spg (in) | As prov (in$^2$) |
|---|---|---|---|---|---|
| Short Direction, Inside | 20.00 | 0.4869 | 0.7874 | 7.87 | 0.74 |
| Long Dir, Inside | 20.00 | 0.4869 | 0.7874 | 7.87 | 0.74 |
| Short Direction, Outside | 16.00 | 0.3116 | 0.6299 | 7.87 | 0.47 |
| Long Dir, Outside | 16.00 | 0.3116 | 0.6299 | 7.87 | 0.47 |

| | | | | | |
|---|---|---|---|---|---|
| phiv = | 0.75 | | | | |
| Base Slab Thickness: | 1.31 | ft | | | |
| Cover (inside) = | 3.00 | in. | Cover (outside) = | 3.00 | in. |
| d (M+) short = | 12.35 | in. = f - cover - 1/2db(short) | d (M-) short = | 12.43 | in. = f - cover - 1/2db(short) |
| d (M+) long = | 11.57 | in. = f - cover - db(short) - 1/2db(long) | d (M-) long = | 11.80 | in. = f - cover - db(short) - 1/2db(long) |
| f'c = | 4.00 | ksi | dmin= | 11.57 | in. |
| bw = | 12.00 | (per linear ft of slab) | | | |

Check Shear in Base Slab

| | | |
|---|---|---|
| Vc = 2*f'c^.5*bw*d | 17.56 | kips |
| PHI*Vc = | 13.17 | kips |
| Vu = Cs*q*a = | 7.89 | **SHEAR CAPACITY O.K.** |

| Check Moment Capacity (Mu (short)+ inside face reinf. ): Mx+ | | | | Check Moment Capacity (Mu (short)- outside face reinf.): Mx- | | | |
|---|---|---|---|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 | As T & S= | 0.28 | in2 | =0.0030bh/2 |
| Asprov = | 0.74 | in2 | **Asprov>As T&S, OK** | As = | 0.47 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.09 | in | | a =As*Fy/(0.85*f'c*b): | 0.70 | in | |
| phif = | 0.90 | | | phi = | 0.90 | | |
| PHI*Mn = | 39.43 | kip*ft | | PHI*Mn = | 24.48 | kip*ft | |
| Mu+ inside face reinf= | 11.51 | **POS MOMENT CAPACITY O.K.** | | ABS Mu- ourside face= | 8.22 | **NEG MOMENT CAPACITY O.K.** | |

| Check Moment Capacity (Mu (long)+ inside face reinf. ): My+ | | | | Check Moment Capacity (Mu (long)- outside face reinf.): My- | | | |
|---|---|---|---|---|---|---|---|
| As T & S= | 0.28 | in2 | =0.0030bh/2 | As T & S= | 0.28 | in2 | =0.0030bh/2 |
| Asprov = | 0.74 | in2 | **Asprov>As T&S, OK** | As = | 0.47 | in2 | **Asprov>As T&S, OK** |
| a =As*Fy/(0.85*f'c*b): | 1.09 | in | | a =As*Fy/(0.85*f'c*b): | 0.70 | in | |
| phif = | 0.90 | | | phi = | 0.90 | | |
| PHI*Mn = | 36.80 | kip*ft | | PHI*Mn = | 25.82 | kip*ft | |
| Mu+ inside face reinf= | 8.77 | **POS MOMENT CAPACITY O.K.** | | ABS Mu- ourside face= | 8.22 | **NEG MOMENT CAPACITY O.K.** | |

# TWO LAYER REBAR RECTANGULAR CONCRETE TANK - WHEEL LOAD APPLIED - COVER > 2'

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**Crack Check - Check maximum spacing of bars (ACI 350 Section 10.6.4)**

| Unfactored Moment: | Load Case 1 |
|---|---|
| M+(short) unfactored= | 3.63 |
| M- (short) unfactored= | -2.59 |
| M+(long) unfactored= | 2.76 |
| M- (long) unfactored= | -2.59 |

| Crack Check (M(short)+ inside face reinf. ): M+x | | | Crack Check (Mu(short)- outside face reinf.): M-x | | |
|---|---|---|---|---|---|
| Asprov = | 0.74 | in2 | As = | 0.47 | in2 |
| d= | 12.35 | in | d= | 11.80 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.005 | | ρ= | 0.003 | |
| ρn= | 0.040 | | ρn= | 0.027 | |
| k= | 0.246 | | k= | 0.207 | |
| j= | 0.918 | | j= | 0.931 | |
| M+ unfactored= | 3.625 | kips.ft | M- unfactored= | 2.589 | kips.ft |
| fs= | 5.170 | ksi | fs= | 5.954 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 7.874 | in | s= | 7.874 | in |
| db= | 0.787 | in | db= | 0.630 | in |
| fs,max= | 20.900 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 21.085 | **OUTSIDE FACE BAR SPACING O.K.** |

| Crack Check (M(long)+ inside face reinf. ): M+y | | | Crack Check (Mu(long)- outside face reinf.): M-y | | |
|---|---|---|---|---|---|
| Asprov = | 0.74 | in2 | As = | 0.47 | in2 |
| d= | 11.57 | in | d= | 12.43 | in |
| n= | 8.04 | | n = | 8.04 | |
| ρ= | 0.005 | | ρ= | 0.003 | |
| ρn= | 0.043 | | ρn= | 0.026 | |
| k= | 0.253 | | k= | 0.202 | |
| j= | 0.916 | | j= | 0.933 | |
| M+ unfactored= | 2.762 | kips.ft | M- unfactored= | 2.589 | kips.ft |
| fs= | 4.218 | ksi | fs= | 5.643 | ksi |
| β= | 1.35 | | β= | 1.35 | |
| s= | 7.874 | in | s= | 7.874 | in |
| db= | 0.787 | in | db= | 0.630 | in |
| fs,max= | 20.900 | **INSIDE FACE BAR SPACING O.K.** | fs,max= | 21.085 | **OUTSIDE FACE BAR SPACING O.K.** |

# SEISMIC DESIGN LOAD

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**

ACI 350-06 Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3-06 Seismic Design of Liquid-Containing Concrete Structures
AASHTO LRFD Bridge Design Specifications 4th Edition, 2007
ASCE 7-05

**Notes:**

## Seismic Design Load -- Parameters

**Liquid-Containing Concrete Structure**

GEOMETRY INFORMATION INPUT:

| | | | | |
|---|---|---|---|---|
| Outside length = | 15.09 | ft | 4600 | mm |
| Outside width = | 6.89 | ft | 2100 | mm |
| Inside Length L= | 13.12 | ft | 4000 | mm |
| Inside Width= | 4.92 | ft | 1500 | mm |
| design liquid depth HL= | 8.20 | ft | 2500 | mm |
| Exterior Wall thickness= | 0.98 | ft | 300 | mm |
| Interior Wall Thickness= | 0.00 | ft | 0 | mm |
| Roof slab thickness= | 1.31 | ft | 400 | mm |
| Floor slab thickness= | 1.31 | ft | 400 | mm |
| # of exterior walls= | 2 | | | |
| # of interior walls= | 0 | | | |
| # of end walls= | 2 | | | |
| design wall height Hw= | 8.20 | ft | 2500 | mm |
| Inside width transverse= | 4.92 | ft | 1500 | mm |

OTHER PARAMETERS:

| | | | |
|---|---|---|---|
| Concrete Weight= | | 0.15 | kcf |
| | I= | 1 | Table 4.1.1(a) |
| | Ri= | 3 | Table 4.1.1(b) |
| | Rc= | 1 | Table 4.1.1(b) |
| Liquid Weight= | | 0.0624 | kcf |
| | g= | 32.2 | ft/s^2 |
| | ρc= | 4.66 | lb-s^2/ft^4 |
| | ρL= | 1.94 | lb-s^2/ft^4 |
| | fc' = | 4000 | pci |
| | Ec= | 3,604,997 | psi |
| longi | $L/H_L$ = | 1.6 | |
| | 2Π/λ= | 0.65 | Figure 9.2.4 page 47 |
| trans | $L/H_L$ = | 0.6 | |
| | 2Π/λ= | 0.63 | Figure 9.2.4 page 47 |
| | Site Class: | D | |
| | $S_S$= | 1.5 | |
| | $S_1$= | 0.6 | |
| | $F_a$= | 1 | ASCE 7-05 (Table 11.4-1) |
| | $F_v$= | 1.92 | ASCE 7-05 (Table 11.4-2) |

## SEISMIC DESIGN LOAD

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### Seismic Design Load -- Step One and Step Two

DESIGN IS BASED ON ACI350.3-06 CHAPTER 4 - EARTHQUAKE DESIGN LOADS

| | | Longitudinal direction: | | | | | Transverse direction | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Step One | | | | | | | | | | | |
| | | | Wr= | 20.47 | Kips | | | | | | |
| | | | Ww= | 48.47 | Kips | | | | | | |
| | | | L/HL= | 1.60 | | | | L/HL= | 0.60 | | |
| | | | ε= | 0.75 | | Equation (9-44) | | ε= | 0.91 | | Equation (9-44) |
| | | | εWw= | 36.56 | Kips | | | εWw= | 44.20 | Kips | |
| | | We= | εWw+Wr= | 57.03 | Kips | | We= | εWw+Wr= | 64.67 | Kips | |
| Step Two | | | | | | | | | | | |
| | total mass of liquid | | WL= | 33.05 | Kips | | | | | | |
| | | | Wi/WL= | 0.64 | | Equation (9-1) | | Wi/WL= | 0.92 | | Equation (9-1) |
| | | | Wi= | 21.05 | Kips | | | Wi= | 30.37 | Kips | |
| | | | Wc/WL= | 0.41 | | Equation (9-2) | | Wc/WL= | 0.16 | | Equation (9-2) |
| | | | Wc= | 13.43 | Kips | | | Wc= | 5.24 | Kips | |

## SEISMIC DESIGN LOAD

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### Seismic Design Load -- Step Three and Step Ten

| | Longitudinal direction: | Exterior walls | | | Transverse direction | Exterior walls | | |
|---|---|---|---|---|---|---|---|---|
| Step 3 to 9 | | | | | | | | |
| | mw= | 37.61 | lb-s^2/ft^4 | | mw= | 37.61 | lb-s^2/ft^4 | |
| | mi= | 66.40 | lb-s^2/ft^4 | | mi= | 35.93 | lb-s^2/ft^4 | |
| | hw= | 4.10 | ft | | hw= | 4.10 | ft | |
| | hi/HL= | 0.38 | | | hi/HL= | 0.44 | | |
| | hi= | 3.08 | ft | | hi= | 3.64 | ft | |
| | h= | 3.45 | ft | | h= | 3.88 | ft | |
| | k= | 3022710.90 | lb/ft^2 | | k= | 2125714.52 | lb/ft^2 | |
| | m= | 104.01 | lb-s^2/ft^4 | Equation (9-10) | m= | 73.54 | lb-s^2/ft^4 | Equation (9-10) |
| | Ti= | 0.04 | s | | Ti= | 0.04 | s | |
| | Tc= | 2.35 | s | Equation (9-14) | Tc= | 1.40 | s | Equation (9-14) |
| | Ts= | 0.77 | s | Equation (9-34) | Ts= | 0.77 | s | Equation (9-34) |
| | $S_{DS}$= | 1.00 | | Equation (9-35) | $S_{DS}$= | 1.00 | | Equation (9-35) |
| | $S_{D1}$= | 0.77 | | Equation (9-36) | $S_{D1}$= | 0.77 | | Equation (9-36) |
| | Ci= | 1.00 | s | Equation (9-32/9-33) | Ci= | 1.00 | s | Equation (9-32/9-33) |
| | Cc= | 0.43 | s | Equation (9-37/9-38) | Cc= | 0.82 | s | Equation (9-37/9-38) |
| Step 10 | | | | | | | | |
| | CiI= | 1.00 | | | CiI= | 1.00 | | |
| | CcI= | 0.43 | | | CcI= | 0.82 | | |
| | Pw= | 12.19 | kips | Equation (4-1) | Pw= | 14.73 | kips | Equation (4-1) |
| | Pr= | 6.82 | kips | Equation (4-2) | Pr= | 6.82 | kips | Equation (4-2) |
| | Pi= | 7.02 | kips | Equation (4-3) | Pi= | 10.12 | kips | Equation (4-3) |
| | Pc= | 5.82 | kips | Equation (4-4) | Pc= | 4.32 | kips | Equation (4-4) |
| | V= | 26.67 | kips | Equation (4-5) | V= | 31.97 | kips | Equation (4-5) |
| | hc/HL= | 0.62 | | Equation (9-5) | hc/HL= | 0.81 | | Equation (9-5) |
| | hc= | 5.06 | | | hc= | 6.66 | | |
| Simplified method: Considering Uniform distribution of shear force: | | | | | | | | |
| Unit base shear | v= | 1.94 | klf | Unit base shear | v= | 1.06 | klf | |
| | q= | 235.95 | psf | | q= | 129.15 | psf | |

## SEISMIC DESIGN LOAD

## General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

## Seismic Design Load + Seismic-Induced Earth Pressure

| | | | |
|---|---|---|---|
| Seismic Design Load: | q= | 235.95 | psf |
| Seismic-Induced Earth Pressure: | qoe= | 1152.97 | psf |
| Total Seismic Lateral Load: | qe= | 1388.92 | psf |

## SEISMIC-INDUCED EARTH PRESSURE

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

**References:**
ACI 350-06 Code Requirements for Environmental Engineering Concrete Structures
ACI 350.3-06 Seismic Design of Liquid-Containing Concrete Structures
AASHTO LRFD Bridge Design Specifications 4th Edition, 2007

**Notes:**

### PARAMETERS FOR EARTHQUAKE-INDUCED EARTH PRESSURE

CALCULATION OF EARTHQUAKE-INDUCED EARTH PRESSURE:

(REF: ASSHTO 2007 - Appendix A11.1.1.1)

MONONOBE-OKABE ANALYSIS

| | | | | | |
|---|---|---|---|---|---|
| Unit weight of soil: | GAMMA = | 115.00 | Lbs/CF | | |
| | t= | 1.31 | feet | | |
| | h= | 5.91 | Feet | | |
| | a = | 8.20 | Feet | | |
| Angle of friction of soil: | PHI = | 30.00 | Degrees: | RAD= | 0.52359878 |
| | THETA = | 16.70 | Degrees: | RAD= | 0.29145679 |
| Angle of friction soil/tank: | DELTA = | 26.00 | Degrees: | RAD= | 0.45378561 |
| Ground acceleration | A = | 0.60 | g | | |
| Horizontal acceleration coef. | kh = | 0.300 | | | |
| Backfill slope angle: | i = | 0.00 | Degrees: | RAD= | 0 |
| Slope of soil face: | BETA = | 0.00 | Degrees: | RAD= | 0 |

## SEISMIC-INDUCED EARTH PRESSURE

### General Information

| | | | |
|---|---|---|---|
| **Project Number:** | 127-1298-15001 | **Designed By:** | BRO |
| **Description:** | TERRIER ROUGE SETTLEMENT UPGRADED | **Checked By:** | RB |
| **Structure:** | SEWER LEACHING FIELD - 1500mm X 4000mm CHAMBER | **Date:** | December 29, 2016 |

### EARTHQUAKE-INDUCED EARTH PRESSURE

SEISMIC ACTIVE EARTH PRESSURE:

$\psi$ = 2.278

Kae = 0.591 Equation (A11.1.1.1-2)

SEISMIC AT-REST EARTH PRESSURE (AASHTO Pg C-87)

Koe = 0.886

SEISMIC FORCE:

Eoe = 9456.774 lb Equation (A11.1.1.1-1)

qoe= 1152.97 plf

USAID/HAITI