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DESIGNING AND CONSTRUCTION OF T-WALL® RETAINING WALL SYSTEM

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ABSTRACT

This work shall consist of the design, manufacture and construction of a T-WALL® Retaining Wall System. T-WALL® is a proprietary wall system that consists of precast reinforced concrete units that have a rectangular face and a stem which extends into the soil mass. Soil/structure interaction is mobilized by friction between the stems and the granular material compacted between them to ensure local stability. External stability computations are made by assuming that the system acts as a rigid body. T-WALL® shall be proportioned to satisfy overturning, sliding, bearing pressure and eccentricity criteria normally associated with gravity structures. Stability computations shall be made at every module level. Internal stability computations are made at each level to demonstrate that the frictional forces gripping the stem exceeds any horizontal force acting on the face of the unit. If the concrete units cannot be pulled out of the soil then the concrete and soil act together to form a composite gravity mass. T-WALL® units come in various sizes to meet the needs of a project. Precast concrete units are shipped to site ready to be installed. The units are designed in accordance with AASHTO and AREMA specifications for reinforced precast concrete. In general, the concrete units are fabricated so they are interchangeable.

T-WALL® may be used where conventional retaining walls, non gravity cantilevered walls, anchored walls, mechanically stabilized earth (MSE) walls, and prefabricated modular walls are considered, and particularly where substantial total and differential settlements are anticipated. T-WALL® is well suited on highway, railway, bridge abutment, waterway, public works, commercial and industrial projects. It is ideal for in side-hill cut applications, fill applications, along stream channels. The vertical joints in T-WALL® act as slip planes, which can accommodate differential settlement in the foundation. This flexibility can minimize the expense of foundation preparation. T-WALL® can accommodate roadway drainage structures, signposts, fences and guardrails. The concrete units can be modified to handle pipe penetrations through the wall.

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1. Introduction

The T-WALL® Retaining Wall System is a hybrid pre-cast modular retaining wall system, which combines the advantages of both a gravity wall structure and an internally stabilized wall structure. The pre-cast units have a rectangular vertical face panel to retain the soil, and a vertically oriented stem which extended into the retained soil mass. The wall system uses both gravity and friction to counteract the loads from the soil retained behind the wall mass. The precast T-WALL® units arrive on the construction site ready to be placed into the structure, and are easily handled by equipment that is usually already on-site for other purposes. T-WALL® structures are built by stacking the individual units in rows and columns, and then backfilling around the units with select backfill. T-WALL® units come in various sizes to meet the needs of a project. The length of the stem is designed to resist the earth pressure on the unit, which increases with the distance from the top of the wall.

The T-WALL® Retaining Wall System provides solutions to a number of earth retention problems commonly encountered on highways, railways, public works, commercial and industrial projects.

2. T-WALL® Design

2.1. Structure Dimensions

T-WALL® units come in various sizes to meet the needs of a project. Typical units have a rectangular face and a stem that extends into the earth being retained. The reinforced concrete unit has a face height of 5.0 ft, a face width of 7.5 ft and stem lengths ranging from 6 to 32 ft. The units can be installed either vertically or on a batter (4V: 1H, 6V: 1H) (Figures 1-1 and 1-2).

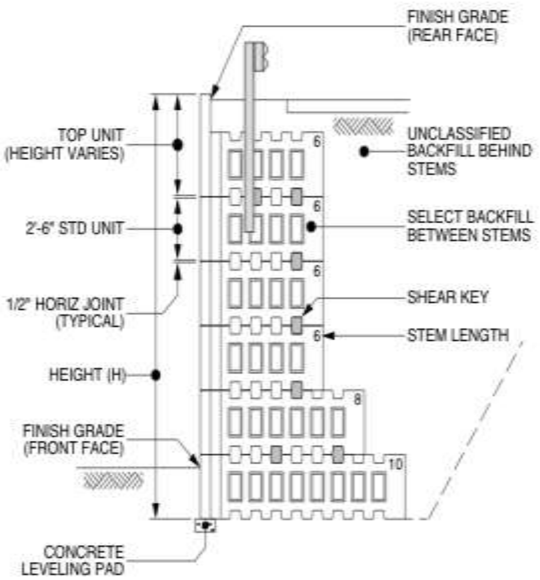

Figure 1. Vertically installed T-WALL® units

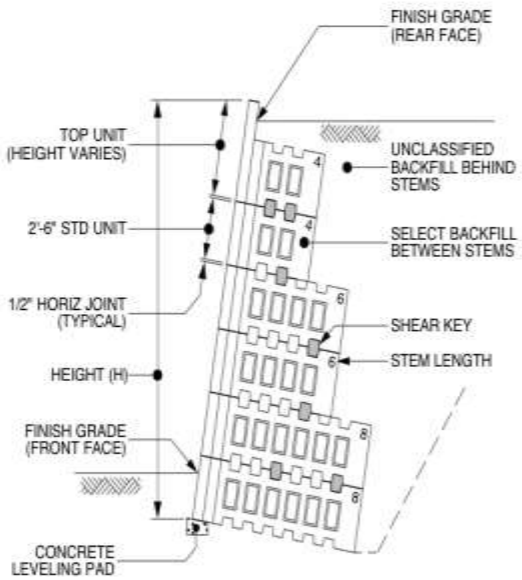

Figure 1-2. Battered T-WALL® units

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2.2. Materials

This section provides the general requirements for materials to be used in the construction of T-WALL® retaining wall.

2.2.1. T-WALL® precast concrete units

2.2.1.1. Concrete

All precast concrete T-WALL® units shall be fabricated using a Portland cement concrete mix, designed and proportioned to meet the requirements set out in the project specifications. Mixes can be standard wet cast mixes, or self-consolidating concrete (SCC) type mixes with a minimum compressive strength of 4,000 psi at 28 days. All concrete shall be normal weight concrete.

2.2.1.2. Rebar

All reinforcing shall be fabricated from deformed steel bars meeting the requirements of ASTM Standard A615.

2.2.2. Joint Material

There are two types of joint materials used in the construction of T-WALL® retaining walls, one for the vertical joints between columns of T-WALL® units, and one for horizontal joints between courses (or levels) of T-WALL® units. Vertical joints require the use of a filter cloth backing between the back of the face panel and the select backfill, extending the full height of the vertical joint. The material used will depend on the T-WALL® application, Horizontal joints require the use of an expansion type joint material between individual units in each column. The type of expansion joint material will also depend on the T-WALL® application..

2.2.3. Precast shear keys and Shear Key Wrap

Precast shear keys shall be made of the same concrete mix as the T-WALL® units and cured in the same manner. Shear Key Wrap ,The shear keys are to be wrapped with a 1/4" closed cell polyethylene foam such as AVI Astro-Foam or equal.

2.3. Primary Design References

AASHTO *Standard Specifications for Highway Bridges*, 6th Edition 2012, with interims.
AREMA –*Manual for Railway Engineering,* 2006 edition.

2.3.1. Design Methodology

Use Load Resistance Factor Design (LRFD) and Allowable Stress Design (ASD) design methodology.

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2.3.2. Stability Analysis

Use the Rankine stability analysis for sliding, overturning and pullout. Minimum factors or safety are:

Sliding	1.5	
Overturning	2.0 soil	1.5 rock
Pullout	1.5	

2.4. External Stability Computation

T-WALL® shall be proportioned to satisfy overturning, sliding and eccentricity criteria normally associated with gravity structures. Stability computations shall be made at every module level. The coefficient of active earth pressure, (Ka), used to compute the horizontal force resulting from the random backfill and other loads shall be computed on the basis of the friction angle of the random backfill using a Rankine state of stress. A passive pressure from soil in front of the wall is not considered in stability computations. (Figure 2)

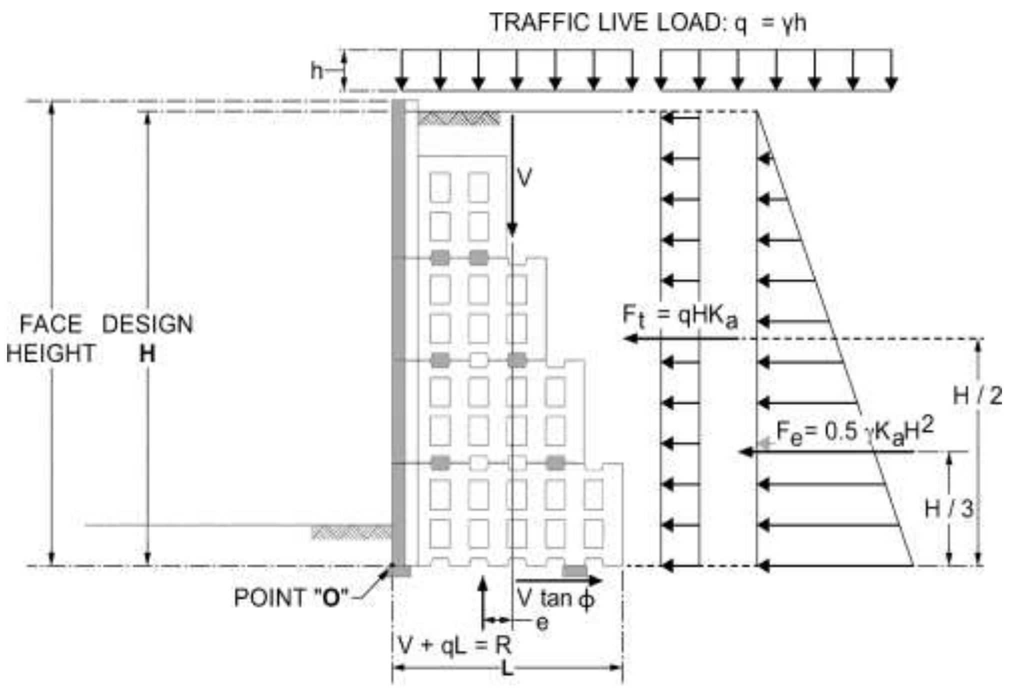

Figure 2. Typical Loading Diagram

2.5. Internal Stability Computation

The stem length at each level shall be sized to resist the horizontal pressure at that level by the weight of the concrete units and by the frictional resistance on the stem. The horizontal pressure shall be computed by multiplying the vertical pressure by an active coefficient of earth pressure (Ka), resisting pressure shall be computed by multiplying the vertical pressure by coefficient of earth pressure at rest (Ko). Computation of the horizontal force within the T-WALL® mass shall be based on a friction angle of specified select backfill in the contract plans. (Figure 3)

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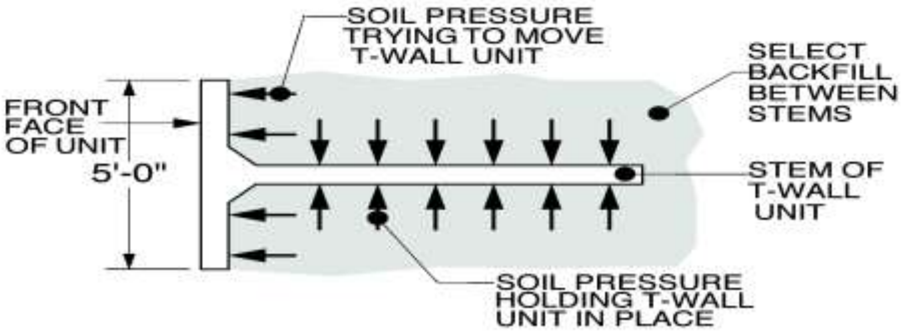

Figure 3. Top View of T-WALL® Unit

2.6. Bearing Resistance and Foundation Stability

Allowable bearing resistance for T-WALL® shall be computed using resistance factors per AASHTO Section 10.5 applied to the calculated nominal bearing resistance. The equivalent width of the footing for nominal bearing resistance calculations shall be the length of the lowest stem (L). The location of the resultant center of pressure shall be within the middle two third of the base (2L/3) for walls founded on soils and middle 9L/10 for walls founded on rock. Bearing pressure shall be computed using the Meyerhof distribution, which considers a uniform base distribution over an effective width of footing B' = L - 2e. (Figure 4)

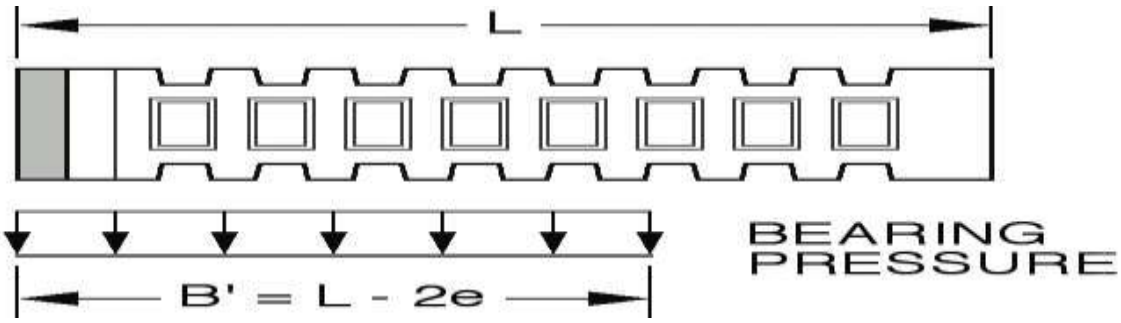

Figure 4. Bearing Pressure Section

2.7. Seismic Design of T-WALL®

T-WALL® stability for seismic loading conditions shall be per AASHTO Section 11 article 11.6.5. The controlling design loads are earth pressure plus seismic load.

The seismic load (pseudo-static Monobe-Okabe model) is an inverted triangular pressure diagram. (Figure 5)

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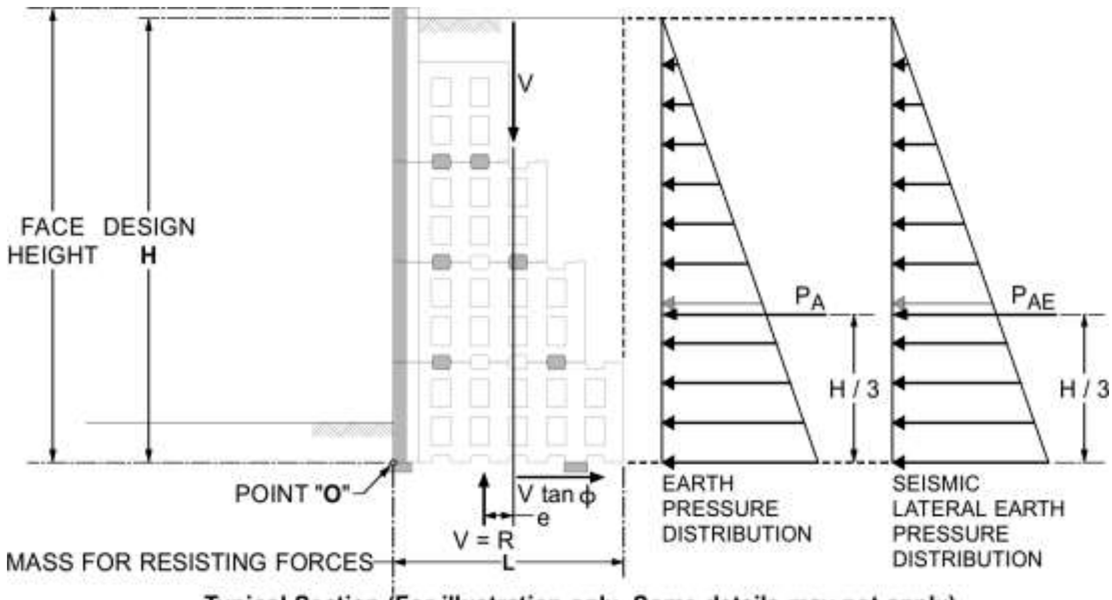

Figure 5. Typical Seismic Loading Diagram

2.8. Select Granular Backfill

The select backfill between the stems is an important part of the T-WALL structure. The select backfill provides the mass needed to resist the lateral loads of the retained soil, the friction to ensure that the select fill and T-WALL units act as one body, and the internal drainage needed to prevent the build-up of hydrostatic pressures on the structure under properly designed, normal site drainage conditions.

• The general gradation requirement of this backfill material is:

Sieve Size	Percent Passing
3 inch	100
3/4 inch	20-100
No. 200	0-25

Locally produced materials with a gradation that falls between the upper and lower limits stated above would be considered satisfactory.

• General Design Parameters

Angle of Internal Friction	32° Minimum
Unit Weight (density)	120 pcf or as specified in the Contract
Compaction -	95% of Standard Proctor, ASTM D-698

If the locally available material meets the gradation and angle of internal friction requirements stated above, but not the unit weight, the wall design may be modified to reflect the actual properties of the available material.

• Backfill between the T-WALL® Units meeting the above criteria may be one of the following locally available materials:

- Crushed or natural sand
- Crushed or uncrushed gravel
- Recycled concrete
- Old ballast

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2.9. Drainage Requirements

T-WALL® has a full height 1/2-inch space with filter cloth backing at every vertical joint along the face of the wall. This space acts as a weep hole and provides sufficient drainage area for water to get out of the wall mass. Therefore no additional weep holes at wall face are necessary for the T-WALL® Retaining Wall System.

3. T-WALL Construction

Precast concrete units are shipped to site ready to be installed. The units are designed in accordance with AASHTO specifications for reinforced precast concrete.. In general, the concrete units are fabricated so they are interchangeable. The units are unloaded using a small crane and lifting device. The basic steps for T-WALL® construction are listed below:

- Begin a T-WALL® project by excavating to the elevation shown on the contract plans.
- Proof roll the foundation, then form and pour the leveling pads.
- Wall construction begins by setting the first course of precast concrete units on the pads, and adjusting them to the correct line and grade. Leaving a half-inch gap between units creates vertical joints, which are covered by filter fabric.
- Spill the select backfill over the stems to ensure that the fill is even on both sides. Spread the fill evenly between stems and compact it to the specified density. Lifts should not exceed 12 inches.
- Next, shear keys wrapped in polyethylene foam are placed in notches on the top of the stems.
- Four rubber pads go on the top of each unit, three on the face, and one near the back of the stem.
- Add the next course of T-WALL®. Level and plumb each unit as necessary.
- A strip of filter fabric goes over each horizontal joint from haunch to haunch. And filter fabric continues upward over the vertical joints.
- The second course is backfilled following the same methods used for the first.
- Rubber pads and shear keys complete the second course
- The steps are repeated for each subsequent course, adding units until the wall structure is complete.

4. T-WALL Retaining Wall System Aplications

The T-WALL® Retaining Wall System provides solutions to a number of earth retention problems commonly encountered on;

- Highway and Roadways
- Railways
- Waterways, Bank Stabilization
- **Bridge Approaches & Abutments**
- Wingwalls
- Site Improvements
- Parking Facilities
- Trash Transfer & Dump Walls

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4.1 Bridge Approaches & Abutments

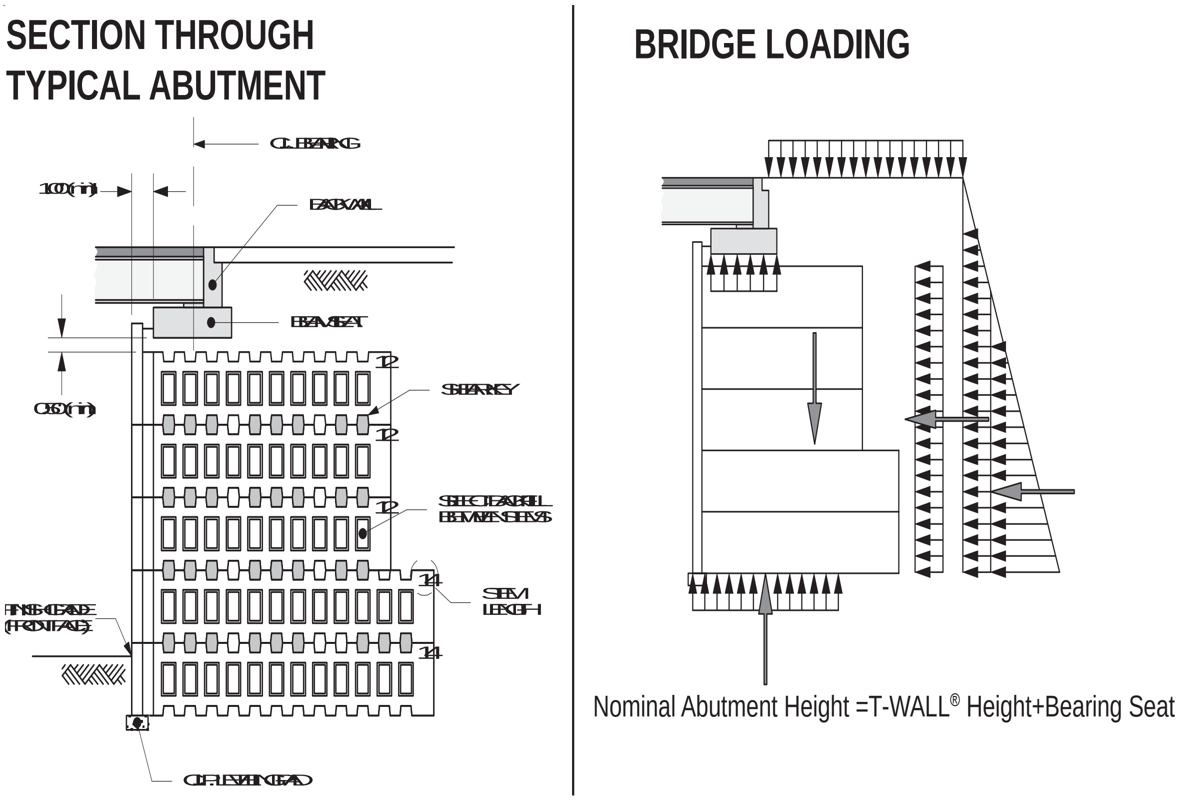

Figure 6. Typical Abutment Section and Loading Diagram

Picture 1. T-WALL Abutment

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The Length of the stem for T-WALL varies in portion to the wall height and loading. Loading may be simple for an ordinary retaining wall (Figure 7), or complex for an abutment, where bridge loads are added (Figure 6). Where settlement is a problem, T-WALL abutments can be designed to accommodate a pile supported bridge (figure 6)

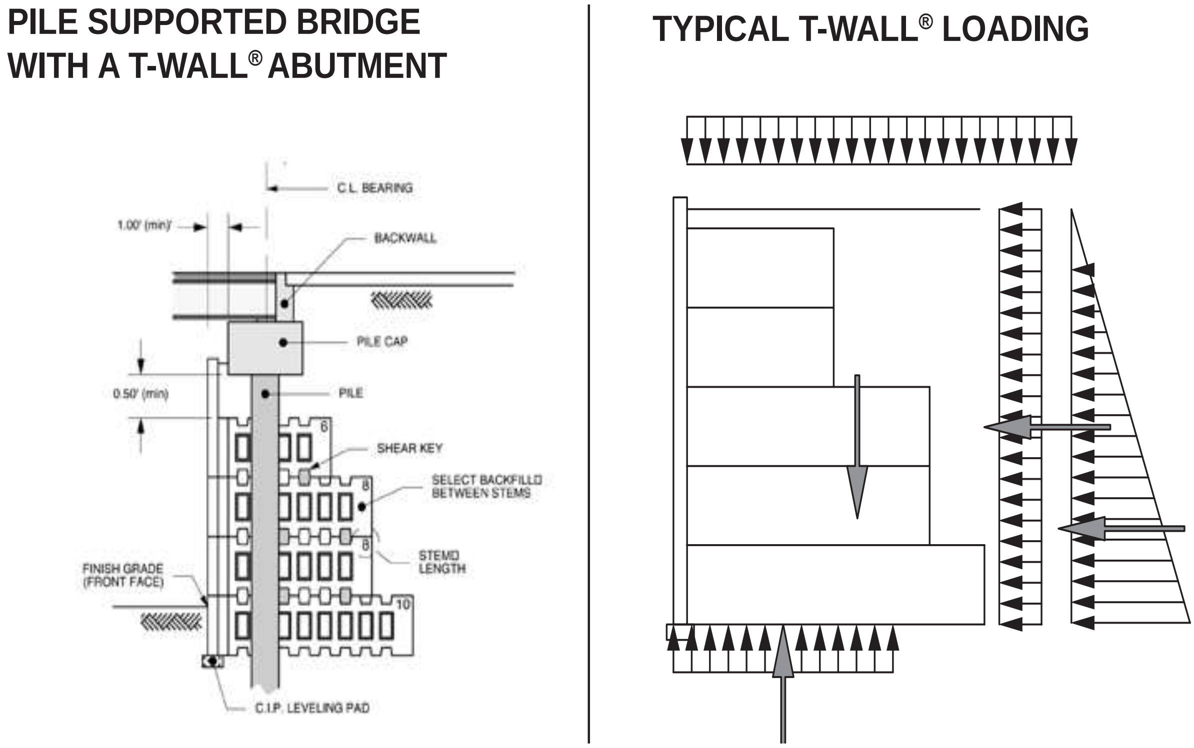

Figure 7. Pile Supported Bridge with T-WALL Abutment and Loading Diagram

Picture 2. Pile Supported Bridge with T-WALL Abutment

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5 Conclusions

T-WALL® Retaining Wall system is based on classical soil mechanics and standard materials concrete and steel. Therefore all the elements of the system have been proven in civil engineering aplications and provides solutions to a number of earth retention problems.

References

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