



**CONSOLIDATED EDISON COMPANY OF NEW YORK, INC.  
4 IRVING PLACE  
NEW YORK, NY 10003**

**DISTRIBUTION ENGINEERING DEPARTMENT**

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05/01/2017**

**STRUCTURAL DESIGN GUIDELINES  
FOR ELECTRIC DISTRIBUTION STRUCTURES**

**FILE: APPLICATION AND DESIGN MANUAL NO. 4, SECTION 2**

**TARGET AUDIENCE**

**DISTRIBUTION ENGINEERING  
REGIONAL ENGINEERING  
ALL SECTIONS**

**NESC REFERENCE**

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## **1.0 INTRODUCTION**

This specification provides the minimum requirements for designing field-poured and precast reinforced concrete structures in Con Edison electric distribution network including but not limited to manholes, vaults and service boxes

## **2.0 APPLICATION**

This specification is applicable to all Con Edison electric operating districts.

## **3.0 REFERENCES**

### **3.1 Industry Standards and Codes**

- 3.1.1** ACI 318-08 (Building Code Requirements for Structural Concrete)
- 3.1.2** ACI 347-04 (Guide to Formwork for Concrete)
- 3.1.3** ACI 370 R-14 (Report for the Design of Concrete Structures for Blast Effects)
- 3.1.4** ASCE 7-10 (Minimum Design Loads for Buildings and Other Structures)
- 3.1.5** ASTM 857-14 (Standard Practice for Minimum Structural Design Loading for Underground Precast Concrete Utility Structures)
- 3.1.6** ASTM 858-09 (Specification for Underground Precast Concrete Utility Structures)
- 3.1.7** Guide for Vehicle Weights and Dimensions –Executive Committee (2003-2004)
- 3.1.8** NYC Building Code (2014)
- 3.1.9** NYS Building Code
- 3.1.10** AISC Steel Construction Manual 14th Edition

### **3.2 Con Edison Electric Operations Specifications**

- [EO-1008](#) Plain and Reinforced Concrete
- [EO-1103](#) Guidelines for Underground Vault Installation in High Water Table Areas
- [EO-100205](#) Purchase Recommendation for Water-stop Material for Watertight Concrete Joints

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## 4.0 DEFINITIONS

4.1 A manhole/service box is an underground structure which houses the Company's distribution electric cable splices.

4.2 A vault is a structure that houses the Company's distribution transformers. Vaults could be located above or below ground, and also inside or outside the customer premises. Vaults located below roadways are known as transformer manholes (TM).

## 5.0 DESIGN LOADS

Hereafter is the list of minimum applicable loads required for designing the structures that are subjects of this specification.

### 5.1 Dead Load (DL)

The dead load consists of the self-weight of the entire structure as well as any other static loads imposed on the structure. Table-1 lists the unit weights of some common construction materials.

Material	Unit Weight lbs./ft <sup>3</sup>
Dry Soil (packed sand and gravel) / Earth Fill	110
Wet Soil ( sand and gravel wet)	120
Submerged Soil (Sand or gravel and clay)	65
Water	62.4
Pavement–(concrete or asphalt)	144
Concrete (reinforced, normal weight)	150
Cast Iron	450
Steel	490
Macadam	140

Table 1- Materials Unit Weights

A minimum additional dead load of 1 foot of accumulated water shall be considered in the design of all structures.

### 5.2 Live Load (LL)

The live load consists of dynamic loads such as vehicles, pedestrians and the weight of movable objects such as distribution equipment.

#### 5.2.1 Roof Live Load For Underground Structures

- a. The surface live load shall be considered as one of below listed cases which generates the maximum internal stresses:

- (1) Uniform load of 600 psf.
- (2) AASHTO HS-20 Wheel Load.

See [Figure 1](#) in Appendix for details including magnitude, spacing, and footprint of the load.

- b. The live load defined in 5.2.1.a. (2) shall be increased to sustain the effect of impact at roadways, sidewalk and driveways.  
See Table 2 for details. (Ref.3.1.5)

Roof Slab Depth below Grade (in.)	Percent Increase
0-12	30%
13-24	20%
25-35	10%
=>36	0%

Table 2 - Impact Factors

**Note:** Impact loads do not need to be included in the design of the footings or piles.

- c. Distribution of wheel load through earth fill:  
Wheel loads shall be distributed below ground level as a truncated pyramid in which the top surface is the wheel load area with a distributed load area as shown in [Figure 2](#). When several distributed load areas overlap, the total load shall be considered as uniformly distributed over the area defined by the outside limits of the individual areas as shown in [Figure 3](#).

### 5.2.2 Roof Loads for Aboveground Structures

The loads shall include snow, drift, and/or any other applicable loads as defined per local and municipal codes.

### 5.2.3 Equipment Live Load

Equipment live load includes the weights of transformers, network protectors, and other equipment.

Table 3 lists the weight and load footprint of transformers and network protector. For other types of equipment refer to the manufacturer manuals.

Equipment Type	Weight	Load Footprint
500 KVA	15,000 lb	2' x 4'
1,000 KVA	25,000 lb	2' x 4'
2,000 KVA	40,000 lb	3.5' x 4.5'
2,500 KVA	40,000 lb	3.5' x 4.5'
Stand Alone NWP	3,500 lb	2 square feet

Table 3 - Equipment Load

**Note: 1)** The equipment on the floor shall be considered in a location that generates the maximum internal stresses. **2)** When analyzing the lateral system of a building that houses the equipment, the equipment weight shall be considered as dead load.

#### 5.2.4 Blast Loads (BL)

- A uniform blast load of 600 psf shall be applied to all the vault elements including walls, roof, and floor slab, except for the elements permanently exposed to soil pressure.
- The following load combination shall be used where the blast load is applicable: **1.2DL + 1.0LL + 1.2BL**

### 5.3 Earth Pressure Load

All underground structures retaining earth fills and/or groundwater shall be designed for the equivalent hydrostatic pressure ([Figure 8](#)). Unless otherwise recommended by the geotechnical report, the following procedure shall be followed.

#### 5.3.1 Pressure from Horizontal Soil Surfaces (above Groundwater Level)

The earth pressure distribution can be approximated by a hydrostatic pressure distribution. The lateral earth pressure at a point on the wall of the structure above the groundwater level is given by the following:

$$P_s = K_a * \gamma_s * H$$

Where:

- $P_s$  = horizontal pressure, (lbf/ft<sup>2</sup>)  
 $K_a$  = coefficient of active earth pressure  
=  $(1 - \sin(\phi)) / (1 + \sin(\phi))$

**Note:** For Con Edison EO standard use  $K_a = 0.33$

- $\emptyset$  = angle of internal friction of the soil (deg.)  
 $\gamma_s$  = unit weight of the soil, (lb/ft<sup>3</sup>)  
H = distance from the ground level to the point on the wall under consideration (ft.)

### 5.3.2 Pressure from Horizontal Soil Surfaces (below Groundwater Level)

Below the groundwater level, the pressure acting on the structure will consist of the hydrostatic pressure and the horizontal pressure resulting from the weight of the submerged soil.

- a. The hydrostatic pressure can be calculated using:

$$P_w = \gamma_w * H_w$$

- $P_w$  = hydrostatic pressure, (lb/ft<sup>2</sup>)  
 $\gamma_w$  = unit weight of water, (lb/ft<sup>3</sup>)  
 $H_w$  = distance from the groundwater level to the point on the wall under consideration (ft.)

- b. The horizontal pressure from the submerged soil at a point on the structure below the groundwater table is given by the following:

$$P_s = (\gamma_s - \gamma_w) * K_a * H_w$$

See [sections 5.3.1](#) and [5.3.2](#) for the variable's definition

### 5.3.3 Pressure from surcharge loads

Earth Pressure from surcharge loads is given by the following:

$$P = K_a * \textit{Surcharge Load}$$

See [Section 5.3.1](#) for variable definition

### 5.3.4 Pressure from Wheel Load

The surcharge pressure resulting from the wheel load is given by the following:

$$P = 0.005 * \textit{Load per wheel}$$

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## 5.4 Other Loads

**5.4.1** Where applicable, all other type of loads (earthquake, wind, snow etc.) shall be considered in the design of the structure.

### 5.4.2 **Lifting Inserts**

Lifting inserts are devices embedded or otherwise attached to the precast structures that shall be designed and manufactured to support a concentrated load equivalent to four times the maximum load transmitted to the insert. The loads imposed at the lifting points shall be considered in the design of the structure.

### 5.4.3 **Buoyancy Effects**

Structures exposed to groundwater shall be checked for buoyancy effects considering only the self-weight of the structure and a safety factor of 1.2.

## 6.0 DESIGN METHODS

**6.1** All concrete structural design calculations shall be performed in accordance with ACI 318 and other applicable codes listed in Section 3.1.

**6.2** All steel structures design calculations shall be performed in accordance with AISC Steel Construction Manual and State/local codes listed in section 3.1.

## 7.0 DESIGN GUIDELINES

### 7.1 Concrete

#### 7.1.1 **Strength of Concrete**

Concrete mix design shall comply with the requirements of [EO-1008](#) and Class 1 concrete defined therein.

#### 7.1.2 **Reinforcement Rebar Detailing and Protection**

Rebar detailing and minimum concrete cover for reinforcement bars shall be as defined in ACI 318.

### 7.2 Steel

The following ASTM designations shall be used for the corresponding structural shapes.

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Structural Steel Shapes	ASTM Designation	Steel Type	Min F <sub>y</sub> (ksi)
W (common beams/columns)	A992	High Strength Alloy	50-65
	A572 Gr. 50		50
C, MC (channels) L, (Angles), Plates	A36	Carbon	36

**Note:** For ASTM designations of other structural steel shapes refer to the AISC Steel Construction Manual, as listed in section 3.1.

### 7.3 Allowable Soil Bearing Capacity

**7.3.1** For Con Edison customer installation, the designer shall provide the geotechnical reports for the foundation type and the soil bearing capacity for review by Con Edison.

**7.3.2** For internal Con Edison design, the allowable bearing pressure values shall be taken from **Table 1804.1**, the NYC Building Code as referenced in [Section 3.1](#). Conservatively, unless organic silts, organic clays, peats, soft clays, loose granular soils, varied silts, controlled and uncontrolled fills are encountered, a value of 1.5 tsf may be used for the soil bearing capacity.

## 8.0 WALL DESIGN

### 8.1 Design Methods

All manhole and vault walls shall be designed using one of the following methods depending on the structure's geometry and layout:

#### 8.1.1 Horizontally Reinforced Rigid Frame Method

In this method the frame is analyzed using conventional indeterminate structural techniques. For rectangular rigid frames, mid-span moments and corner moments are calculated using the coefficients for each moment, given in [Figure 4 to Figure 6](#).

### 8.1.2 Vertically Supported Reinforced Structure Method

In this method the wall is analyzed as a simply supported strip with a height being equal to the headroom of the manhole plus half of the sum of the floor and roof thicknesses. This method requires a roof connection that can adequately carry the wall lateral reaction and all applicable vertical loads.

### 8.1.3 Combination of a Horizontally Rigid Frame and Vertically Reinforced Designs

When dictated by specific conditions, such as major openings, a combination of 8.1.1 and 8.1.2 shall be applied.

## 8.2 Wall Limitations

**8.2.1** All new field-poured vertically reinforced vaults and manholes shall have a minimum wall thickness of 7 inches (8 inches if cast against the soil.)

**8.2.2** All new field-poured horizontally reinforced rigid frame type vaults and manholes shall have a minimum wall thickness of 8 inches (9 inches if cast against the soil.)

**8.2.3** Partition walls in field-poured vaults shall have a minimum thickness of 10 inches to provide adequate bearing support for roofs.

**8.2.4** Where watertight construction is required, structures shall be constructed as the following:

**8.2.4.1** The walls shall be monolithically poured with the floor slab.

**8.2.4.2** The minimum distance for construction joints (if needed) shall be at the greater of the following locations:

- 12 inches above the top of the floor level.
- 12 inches above the groundwater level.

A water stop shall be inserted at this location as shown on [Figure 7](#).

**8.2.4.3** A minimum wall thickness of 12 inches is required for all field poured vault construction.

## 9.0 ROOF DESIGN

**9.1** The roof steel beams shall be designed as simply supported members. The design span shall be taken as the clear span plus a minimum of eight inches or half of the add wall thickness.

**9.2** With the exception of service box structures, the minimum thickness of precast and field-poured roofs shall be 6 and 8 inches respectively.

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## 10.0 FLOOR DESIGN PROCEDURE

The following procedure shall be used in the design of reinforced concrete floors for field-poured and precast manholes and vaults. The floor design shall be consistent with the geotechnical report and foundation recommendation.

### 10.1 Slab on Grades

When maximum pressure resulting from all applicable loads does not exceed soil bearing capacity as defined in Section 7.3, a slab on grade design can be considered. In this condition, the floor slab shall be designed as being capable of resisting an upward uniform force resulting from total dead plus live loads (excluding floor self-weight and equipment weight, if the equipment is not suspended from the walls) divided by the floor area.

When applicable, the upward hydrostatic pressure on the floor shall be considered in the design.

### 10.2 Structural Slab

When maximum pressure resulting from all applicable loads exceeds soil bearing capacity as defined in Sections 7.3, the slab shall be designed to span between the supports (i.e. pile caps, foundations, etc.) or be fully supported by an appropriately designed mat/pile cap.

## 11.0 FLOOR LIMITATIONS

The floor thickness shall adhere to the design requirements but shall not be less than the following (except the service box structures as defined by the structure engineer)

- 6" thick for precast structures
- 8" thick for field-poured manholes
- 10" thick for field-poured vaults on soil
- 8" thick for field-poured vaults on rock
- 6" thick for field-poured vaults on steel frame

## 12.0 MANHOLE DESIGN LIMITATIONS

For standard Con Edison manhole structures, a minimum surcharge load of 4 feet of soil shall be considered for the design of the roof slab and walls.

Maged Filtes- Sr. Engineer

Mohsen Shaaker (Signature on File)  
Mohsen Shaaker- Manager

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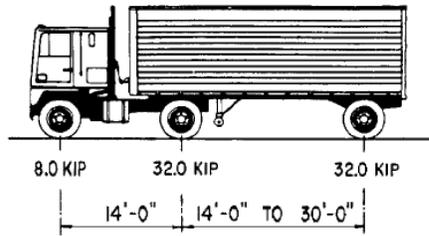
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# Appendix

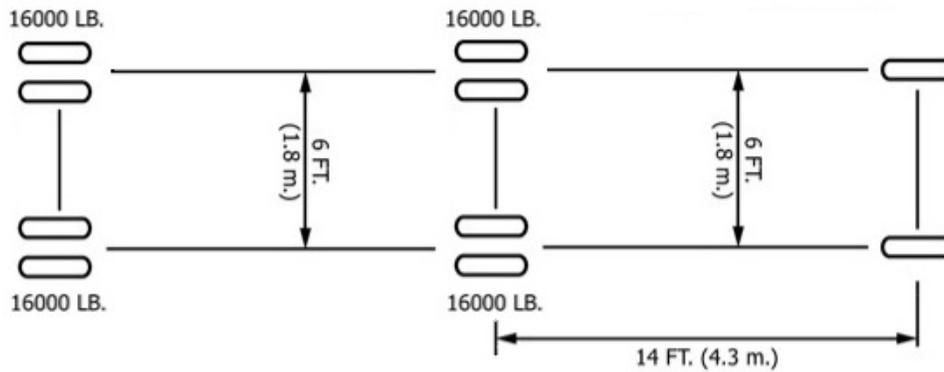
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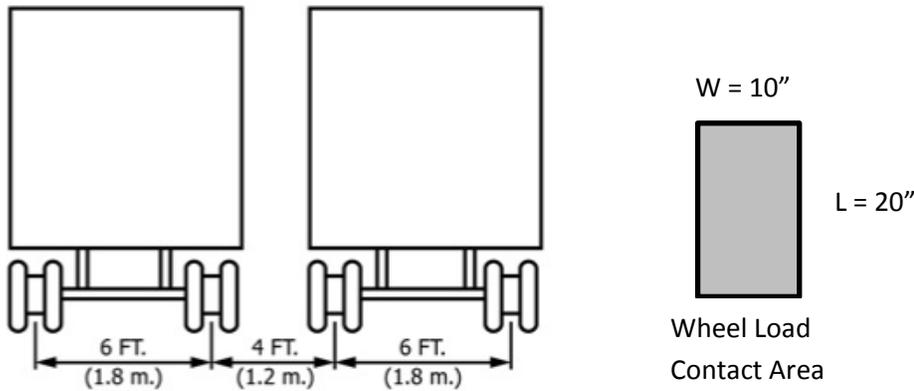


Figure 1 - Wheel Load area and HS-20 Loading

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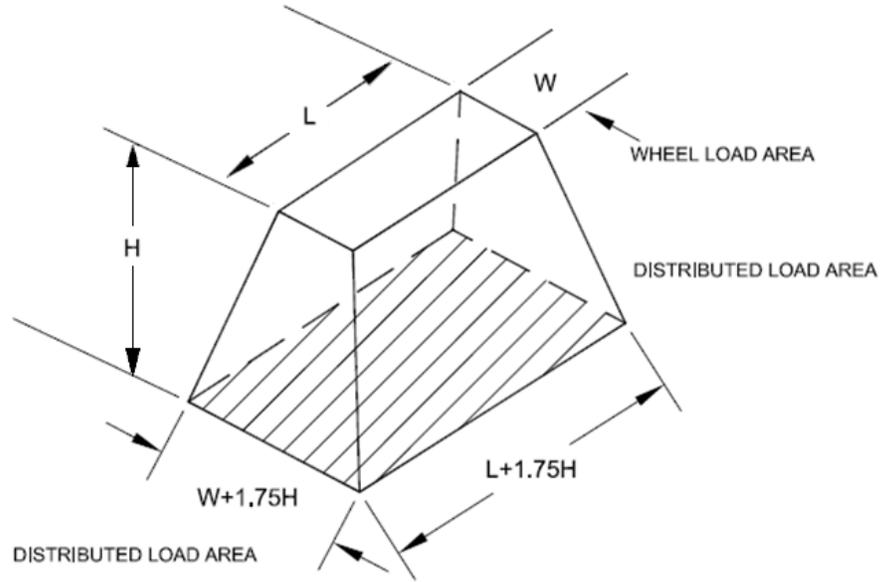


Figure 2 - Distributed Load Area

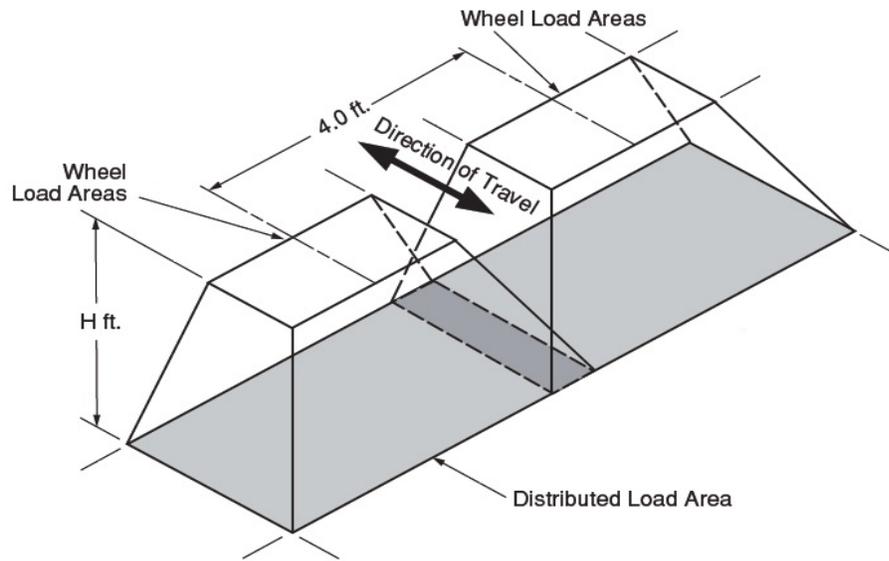


Figure 3 – Overlapping Load Areas

## CORNER MOMENT COEFFICIENT

$$M_C = K_1 w L_1^2$$

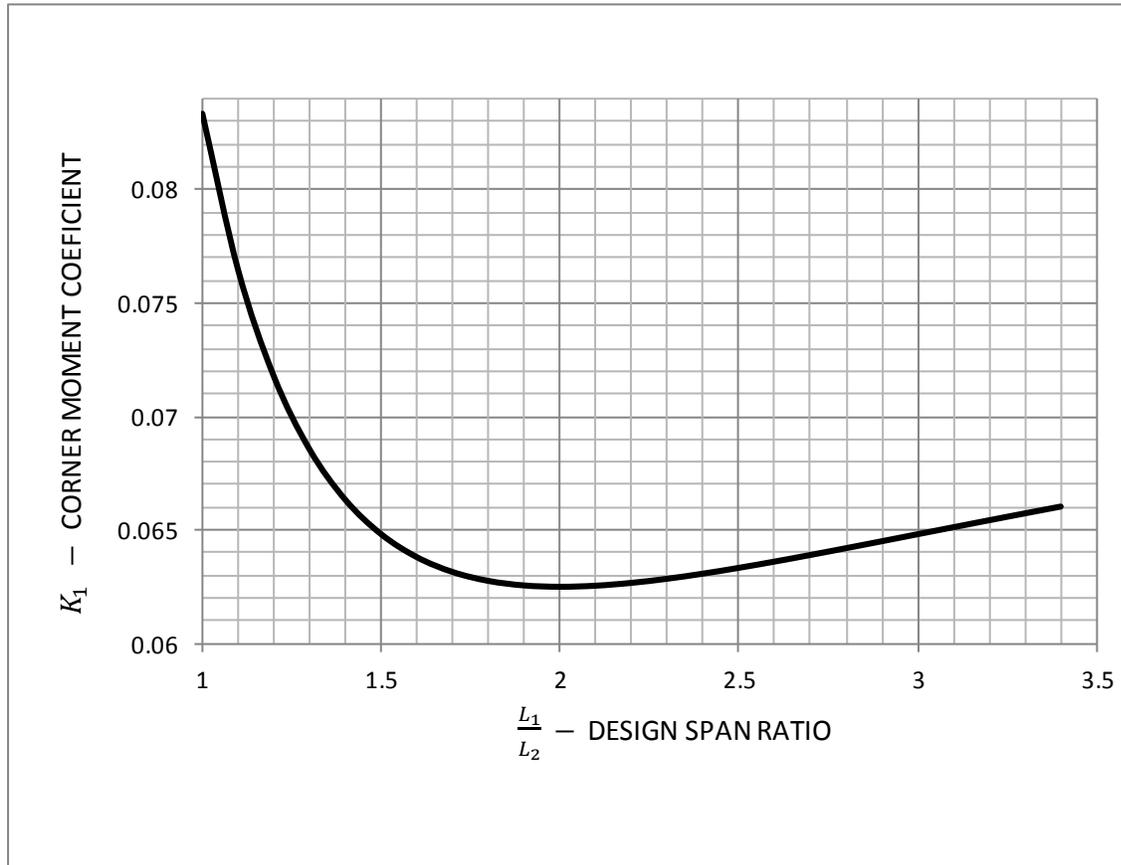


Figure 4 - Corner Moment Coefficient



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## LONG SPAN MOMENT COEFFICIENT

$$M_p = K_2 w L_1^2$$

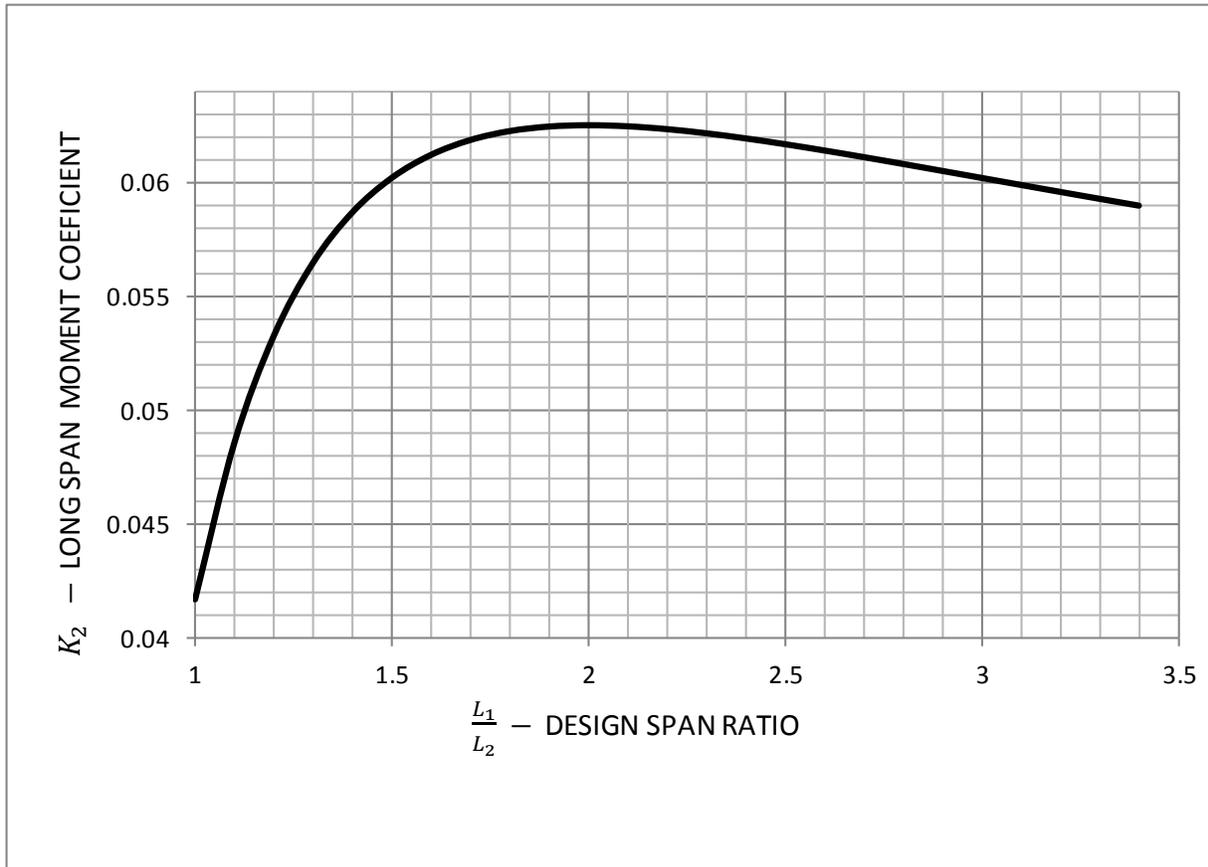
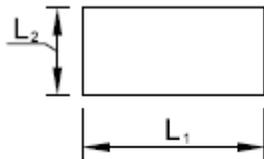


Figure 5 - Long Span Moment Coefficient



$L_1$  = LONG SPAN  
 $L_2$  = SHORT SPAN



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## SHORT SPAN MOMENT COEFFICIENT

$$M = K_3 w L_1^2$$

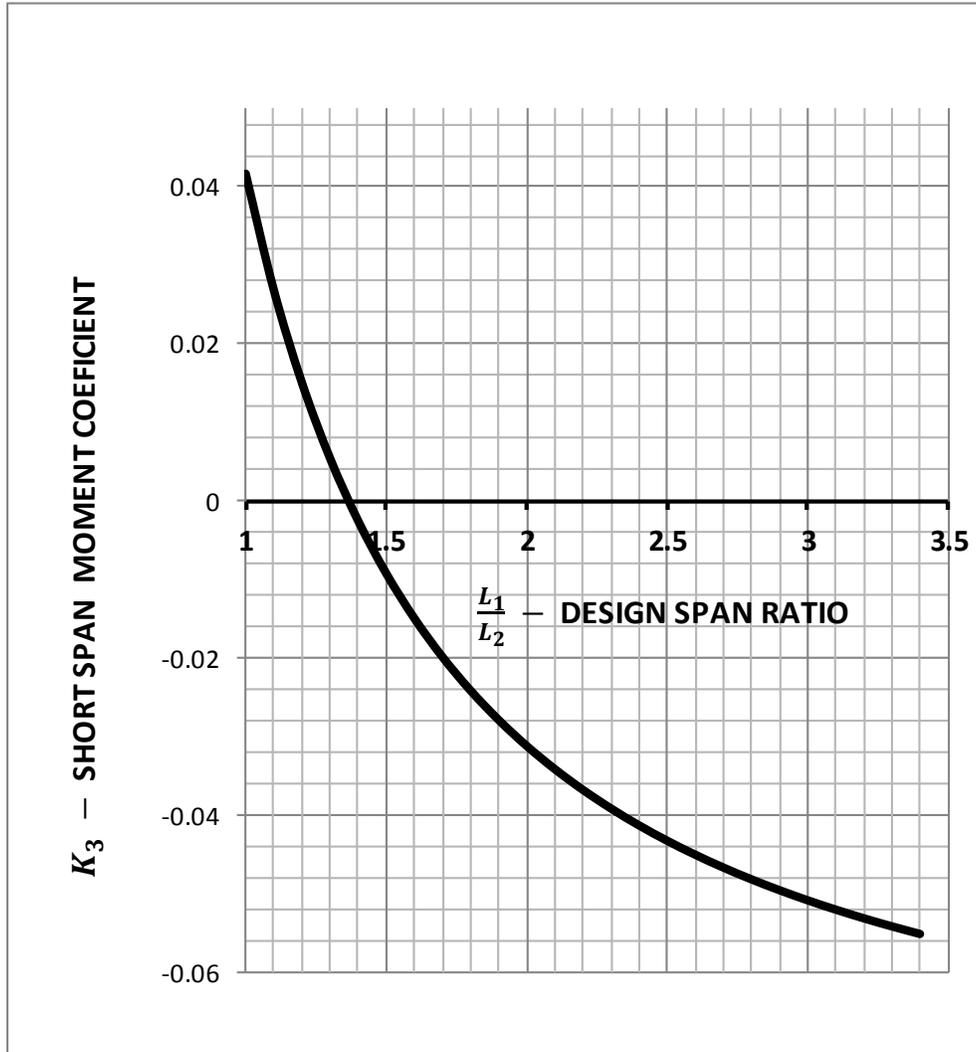


Figure 6 - Short Span Moment Coefficients



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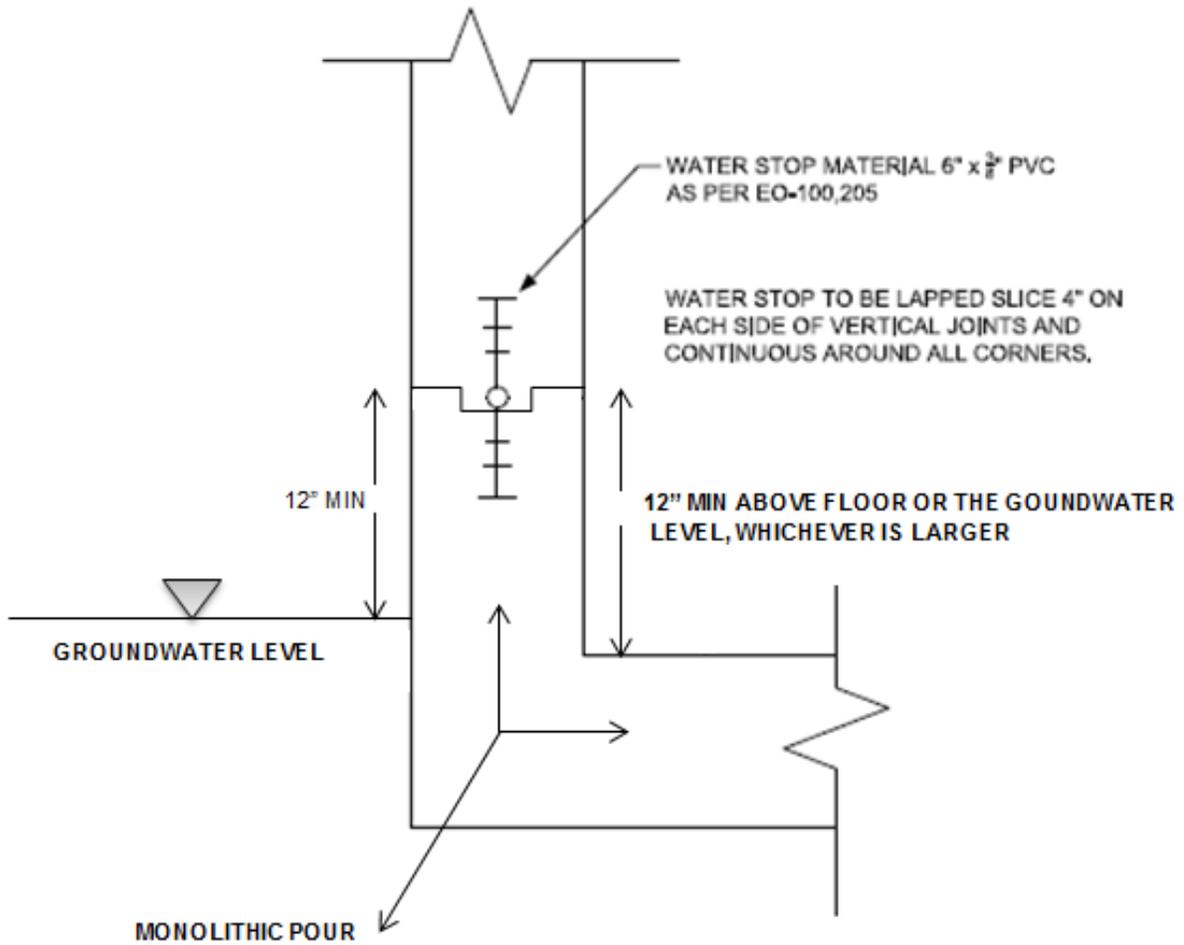


Figure 7 - Waterstop Detail

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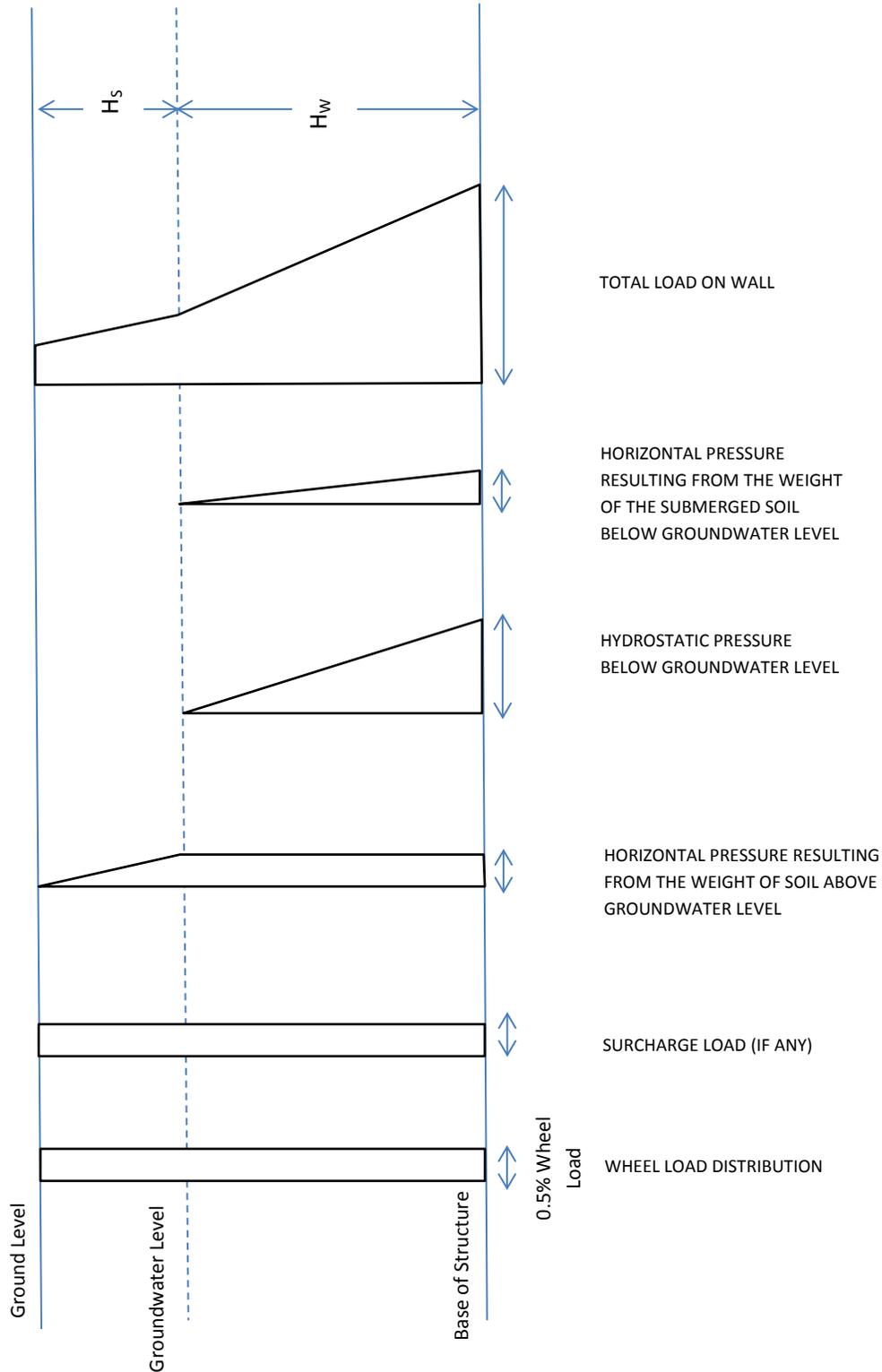


Figure 8 - Wall Load Diagram

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