TEK 14-17: CONCRETE MASONRY CANTILEVER HIGHWAY NOISE BARRIER WALLS (1986)

Keywords:	cantilever noise barrier, highway, noise, noise barrier, sound, sound attenuation

Introduction

Over the past decade, the need for noise abatement along our nation's highway systems has become increasingly important. High volume, high speed traffic located in close proximity to high density populated residential areas has resulted in an ever increasing number of people being exposed to excessively high noise levels. While several measures have been proposed to lessen the impact of traffic noise on surrounding communities, the installation of highway noise barriers is the abatement method most commonly employed.

Although many different types of materials have been utilized in the construction of these barriers, concrete masonry, with an almost limitless variety of surface textures, colors, and patterns has proven to be more effective for a various number of reasons.

1. Concrete masonry is aesthetically pleasing. The availability of a multitude of sizes and shapes, as well as the use of integral coloring or stains, make it possible to create features designed to blend well with any type of physical surroundings. It remains attractive throughout the years with no additional surface treatments.

2. It possesses a high degree of structural integrity as witnessed by the fact that many of today's high rise buildings are being constructed of load-bearing concrete masonry.

3. Properly designed and constructed, concrete masonry has an outstanding performance record for durability.

4. Most importantly, it can provide the above listed features at only a fraction of the cost of competitive materials. Alternate bids on highway noise barrier projects in various parts of the country have shown masonry to enjoy a 2-1 to 3-1 cost advantage.

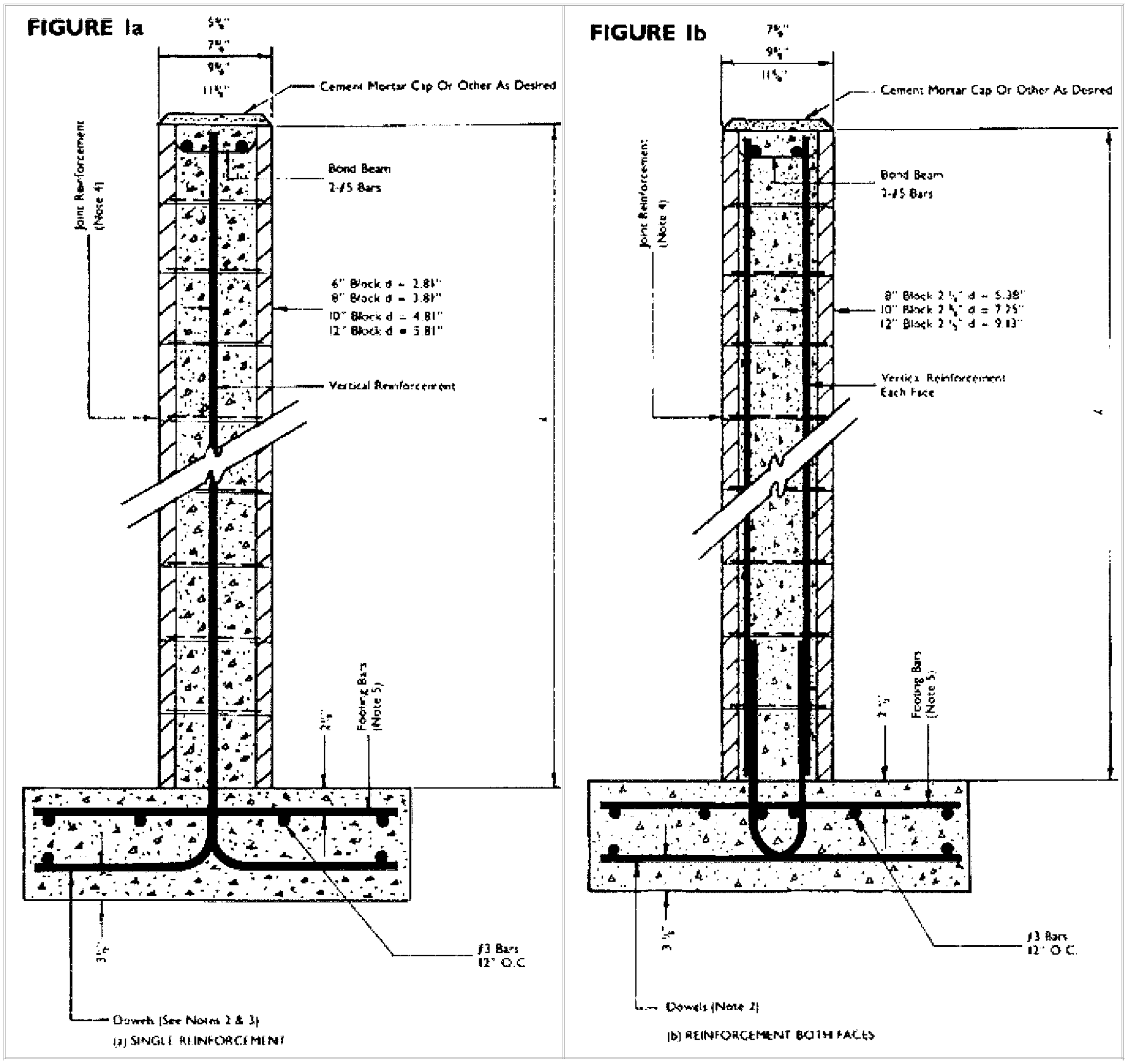
Several construction techniques may be employed in the erection of concrete masonry walls for use as sound barriers. NCMA-TEK 127 provides a design criteria for pier and panel walls. The purpose of this TED is to provide information on the structural design of cantilevered walls constructed on conventional footings.

Materials and Workmanship

Since concrete masonry highway noise barrier walls will be subjected to a wide range of temperatures, moisture, and lateral load conditions, the selection of proper materials and workmanship is very important to ensure durability and satisfactory structural performance. Accordingly, it is recommended that all materials and construction practices comply with applicable requirements contained in the latest revision of ACI 531-79 "Building Code Requirements for Concrete Masonry Structures."

Lateral Loads

Design lateral loads should be in accordance with those specified by local or state building and highway officials. If design lateral loads are not specified, it is recommended that loads be selected conforming to those specified in "American National Standard Minimum Design Loads for Buildings and Other Structures," ANSI A58.1-1982.



Structural Design Considerations

The effects of lateral and gravity loads on concrete masonry noise barrier walls must be considered in determining the required resistance of the wall to bending and shear. In the case of a cantilevered wall, both the bending moment and shear are at a maximum at the intersection of the wall with the footing.

Other factors which must be considered are the resistance to overturning of the footing about the toe and the ability of the soil beneath the footing to resist the bearing pressures created by the combination of lateral and gravity loads.

This TEK covers only the required size and spacing of the vertical wall reinforcement to resist the lateral loads imposed by the wind pressure acting against the face of the wall.

Lateral loads may be directed at either face of the wall; therefore, the wall must be designed to resist bending and shear from either direction. The resistance to flexure is determined by:

1. The size, spacing and strength of the vertical reinforcement.
2. The effective depth (d) of the reinforcement measured from the compressive face of the wall to the center of the vertical bars.
3. The compressive strength of the masonry.

The wall's resistance to shear is determined by the net section (net cross sectional area of mortar bedded plus grouted areas) and the compressive strength of the masonry.

The height of the wall and the magnitude of the lateral load to which it is exposed will usually determine if steel placed along the center line of the wall will suffice, or if the steel will be required adjacent to the inside faces of both sides of the wall.

An example of concrete masonry noise barriers along a highway near a housing development south of San Francisco. Panels 8'x 20' were preassembled utilizing concrete block with three scores on one face of the wall contrasted with a smooth face on the reverse side.

The design of the reinforced concrete footing should be governed by the requirements of the American Concrete Institute. For guidance, consult the latest revision of ACI Standard 318 car Reinforced Concrete Design Handbooks.

Design Criteria

Design assumptions and wall design criteria used in the preparation of Tables 1, 2, 3, and 4 are as follows:

Wall Design Criteria

Allowable Design Stresses: Based on ACI 531 Table 10.1 and Section 10.1.6 including 33 percent allowable stress increase for wind.

Flexural Compressive Stress in Masonry, F_b

$F_b = 0.33 \times f'_m \times 1.33$ 1200 psi maximum

Allowable Shear Stress in Masonry, F_v

$F_v = 1.1 \times \sqrt{f'_m}$ 50 psi maximum

Tensile stress in Reinforcement, F_s

F_s = 20,000 x 1.33 psi grade 40

F_s = 24,000 x 1.33 psi grade 60

Flexural Design Criteria

The allowable resisting moment, Mr must exceed the design moment, M due to lateral wind pressure.

Design Moment Due to Wind Pressure

$$M = \frac{w \times h^2}{2} \text{ ft-lbs/ft of wall}$$

w = Design Wind Pressure, psf

h = Height of wall, feet

Allowable Resisting Moment

M_r = lesser of M_s or M_m
$M_s = F_s A_s j d$ in-lbs/ft Steel Governs

Shear Design Criteria

The resisting shear, Vr must exceed the design shear, V due to wind pressure.

Design Shear Due to Wind Pressure:

V = w h (lb per ft of wall)

Resisting Shear:

$V_r - F_v b d$ (lb per ft of wall)

Table 1 - 6 Inch Noise Barrier Wall				
Wall Height ft.	W=10 psf Vertical Reinforcement	W=15 psf Vertical Reinforcement	W=20 psf Vertical Reinforcement	W=25 psf Vertical Reinforcement
10 12 14 16 18 20	#5@48 #6@40 #7@24 #8@8 - -	#6@40 #7@16 - - - -	#6@16 - - - - -	#7@8
Table 2 - 8 Inch Nose Barrier Wall				
Wall Height ft.	W=10 psf Vertical Reinforcement	W=15 psf Vertical Reinforcement	W=20 psf Vertical Reinforcement	W=25 psf Vertical Reinforcement
10 12 14 16 18 20	#5@48 #5@48 #6@48 #7@48 2-#7@48 2-#7@40	#5@40 #7@48 #8@40 2-#7@48 2-#8@48 2-#8@24	#6@48 #8@48 2-#7@48 2-#8@40 2-#8@24 2-#7@8	#7@48 2-#7@48 2-#8@48 2-#8@24 2-#7@8 -
Table 3 - 10 Inch Nose Barrier Wall				
Wall Height ft.	W=10 psf Vertical Reinforcement	W=15 psf Vertical Reinforcement	W=20 psf Vertical Reinforcement	W=25 psf Vertical Reinforcement
10 12 14 16 18 20	#4@48 #5@48 #6@48 #6@48 #7@48 #8@48	#5@48 #6@48 #7@48 #8@48 2-#7@48 2-#8@48	#6@48 #7@48 #8@48 #7@48 2-#8@48 2-#8@48	#6@48 #8@48 2-#7@48 2-#8@48 2-#8@48 2-#8@48
Table 4 - 12 Inch Nose Barrier Wall				
Wall Height ft.	W=10 psf Vertical Reinforcement	W=15 psf Vertical Reinforcement	W=20 psf Vertical Reinforcement	W=25 psf Vertical Reinforcement

10	#4@48	#5@48	#5@48	#6@48
12	#4@48	#5@48	#6@48	#7@48
14	#5@48	#6@48	#7@48	#8@48
16	#6@48	#7@48	#8@48	2-#7@48
18	#6@48	#8@48	2-#7@48	2-#8@48
20	#7@48	#8@48	2-#8@48	2-#8@48

General Notes:

1. Reinforcement of a size and spacing other than given in the tables may be used, providing such other requirement furnishes an area of steel at least equal to that indicated in the tables.
2. Dowels shall be at least equal in size and spacing to the vertical stem reinforcement, shall project a minimum of 48 bar diameters into the filled block cores, and shall extend to the toe of the footing.
3. Alternate dowels shall extend in opposite directions.
4. Joint reinforcement consisting of 9ga. longitudinal wire and 3/16" cross rods shall be provided at 8" centers vertically.
5. Size and spacing of footing bars shall be in accordance with the latest revisions of ACI Standard 318.