CEMP-ET Engineer Technical Letter 1110-3-446	Department of the Army U.S. Army Corps of Engineers Washington, DC 20314-1000	ETL 1110-3-446 20 August 1992
	Engineering and Design REVISION OF THRUST BLOCK CRITERIA IN TM 5-813-5/AFM 88-10, VOL.5 APPENDIX C	
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DEPARTMENT OF THE ARMY
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Engineer Technical
Letter No. 1110-3-446

20 August 1992

Engineering and Design
REVISION OF THRUST BLOCK CRITERIA IN
TM 5-813-5/AFM 88-10, VOL. 5
APPENDIX C

1. Purpose. The purpose of this ETL is to provide design engineers with criteria that will be used in preparing designs and project specifications for construction of thrust blocks for underground water and wastewater piping at facilities for the Army and the Air Force. This ETL promulgates, as well as supplements, criteria found in HQUSACE Architectural and Engineering Instructions, Design Criteria, and shall be compatible with and reflect criteria found in Air Force Manual AFM 88-15. This letter is a revision of Appendix C of TM 5-813-5/AFM 88-10, Vol. 5. The enclosed revision should be used for thrust block calculations until the criteria is incorporated into the applicable manual.

2. Applicability. This letter applies to HQUSACE elements, major subordinate commands (MSC), districts, and field operating activities (FOA) having Army and Air Force military construction and design responsibility.

3. Discussion. Appendix C of TM 5-813-5/AFM 88-10, Vol 5, Titled: Water Supply, Water Distribution, incorrectly used bearing capacity in calculating the lateral restraint for thrust blocks. In another part of Appendix C, the use of full passive pressure was incorrectly used to calculate the lateral restraint for thrust blocks.

4. Implementation. This letter will have routine application as defined in paragraph 6C, ER 1110-345-100.

FOR THE DIRECTOR OF MILITARY PROGRAMS:

Encl

RICHARD C. ARMSTRONG, P.E.
Chief, Engineering Division
Directorate of Military Programs

APPENDIX C

THRUST RESTRAINT

C-l. General. Thrust forces occur in waterlines when the pipeline changes directions, changes sizes, or stops. Thrust blocks or restrained joints are used to resist thrust forces. The geotechnical parameters used herein should be developed by a geotechnical engineer.

C-2. Thrust Forces. The magnitude of the thrust force may be calculated by:

T = 2PA Sin ⌀/2 at bends;
or by:
T = PA at deadends, branches, or tees.
Where,
T = thrust force in pipe,
P = internal pressure of pipe,
A = internal cross-sectional area of pipe, and
⌀ = angle of deflection of bend.

These are shown in Figures C-l, C-2 and C-3.

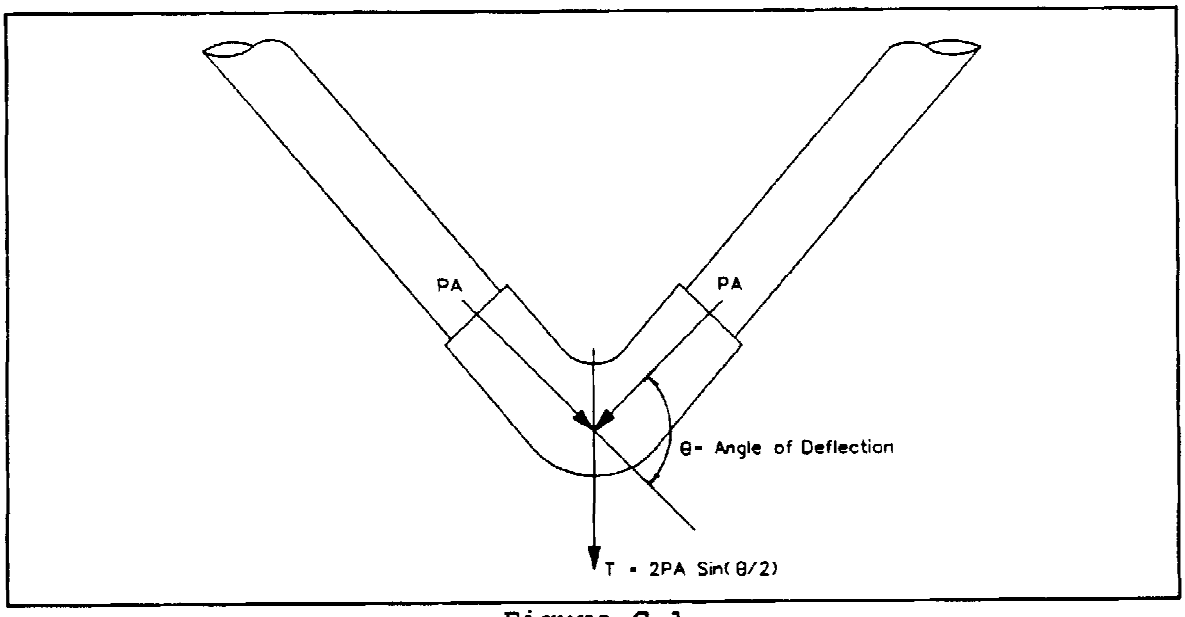

Figure C-1

C-3. Thrust Blocks for Horizontal Bends. Refer to paragraph C-7 for sketches. The size of thrust block is calculated by;

$$A_{TB} \geq F_S[T - f(W_S + W_{TB})]/(_S Z R K_P$$

where;
A_{TB} = area of thrust block,
T = thrust force in pipe,
f = friction coefficient for concrete cast on soil; varies with type of soil; refer to Table C-1,
W_S = weight of backfill,
W_{TB} = weight of thrust block,
$(_S$ = unit weight of soil,
Z = embedment depth to bottom of thrust block,
R = reduction factor applied to Kp (reference 4),
F_S = factor of safety,
K_P = coefficient of passive pressure for undisturbed soil of trench sidewall, preferably determined using the log-spiral method (reference 4).

In the absence of information regarding maximum allowable displacement of pipe and pipe joints, use K_o instead of RK_P. The above formula is then;

$$A_{TB} \geq F_S[T - f(W_S + W_{TB}]/(_S Z K_0$$

where;
K_o = coefficient of at-rest pressure.

For a conservative approach, the term $f(W_s + W_{TB})$ may be neglected resulting in either $A_{TB} \geq F_S T/(_S Z R K_P$ or; $A_{TB} \geq F_S T/(_S Z K_0$.

C-4. Thrust Blocks for Vertical Bends. Refer to paragraph C-B for sketches.

C-4.l. The size of thrust block for upward directed thrust is calculated by;

$$V_{TB} \geq F_S(T_y - W_W - W_J - W_S)/(_C$$

where;
V_{TB} = volume of thrust block,
T_y = vertical component of thrust force=2PA Sin 0/2 Cos 0,
W_W = weight of water in joint,
W_J = weight of pipe joint,
W_S = weight of soil or backfill over thrust block,
$(_C$ = unit weight of concrete, and
F_S = Factor of Safety.
For a conservative approach, the terms W_W, W_J, and W_S, may be neglected resulting in $V_{TB} \geq F_S T_y/(_C$.

TABLE C-l

Friction Coefficient for Concrete Cast on Soil
(reference 4)

Interface Materials	Friction Coefficient, f
Mass concrete on the following foundation materials:	
Clean sound rock	0.70
Clean gravel, gravel—sand mixtures, coarse sand	0.55 to 0.60
Clean fine to medium sand, silty medium to coarse sand, silty or clayey gravel	0.45 to 0.55
Clean fine sand, silty or clayey fine to medium sand	0.35 to 0.45
Fine sandy silt, nonplastic silt	0.30 to 0.35
Very stiff and hard residual or preconsolidated clay	0.40 to 0.50
Medium stiff and stiff clay and silty clay	0.30 to 0.35

C-4.2. The size of thrust block for downward directed thrust is calculated by;

$$A_{TB} \geq F_S T_Y / q_S$$

where;

A_{TB} = bottom area of thrust block,
T_y = vertical component of thrust force,
q_S = allowable bearing capacity of soil, and
F_S = Factor of Safety.

C-4.3. There is also a horizontal component of thrust (T_x) in vertical bends. The sizing of thrust block for the horizontal component is calculated by the same formula used for horizontal bends, except the term T is replaced by T_x = 2PA Sin 0/2 Cos 0.

C-4.4. These are shown in Figures C-4, C-5, C-6 and C-7.

C—5. Restrained Joints. There are several approaches to this. They all calculate the length of pipe to be restrained on both sides of the joint. The length to be restrained may be determined by;

$$L \geq F_S(PA \tan 2/2)/(F_f + 0.5\ R\ (_S\ Z\ K_p\ D_o)$$

where;

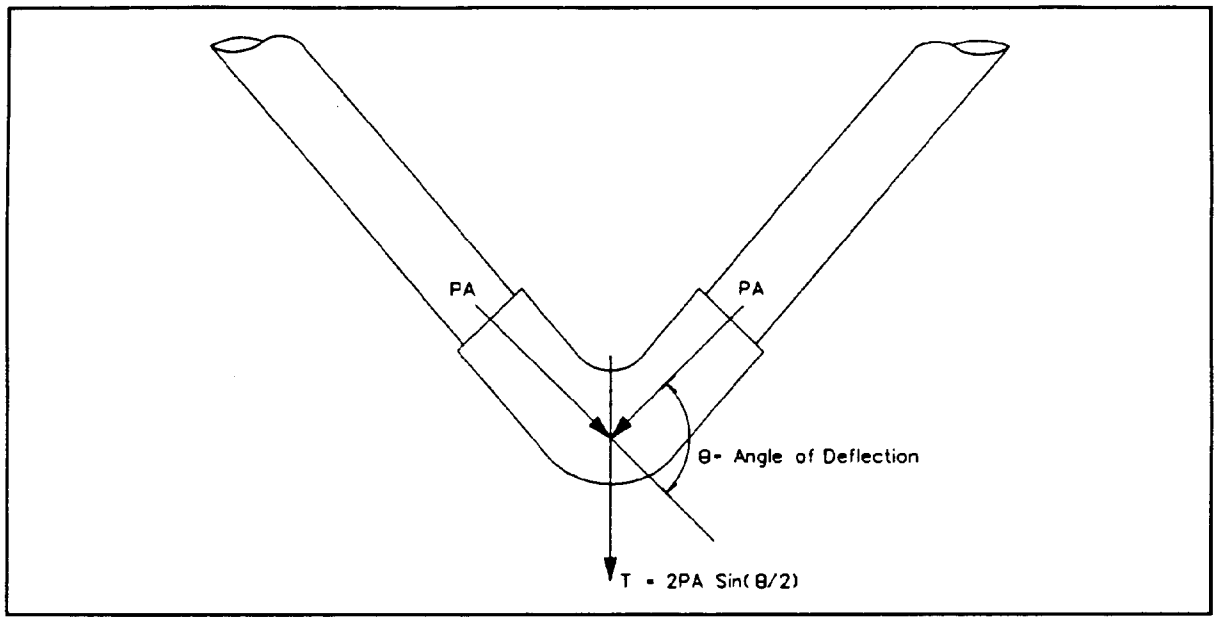

Figure C-4

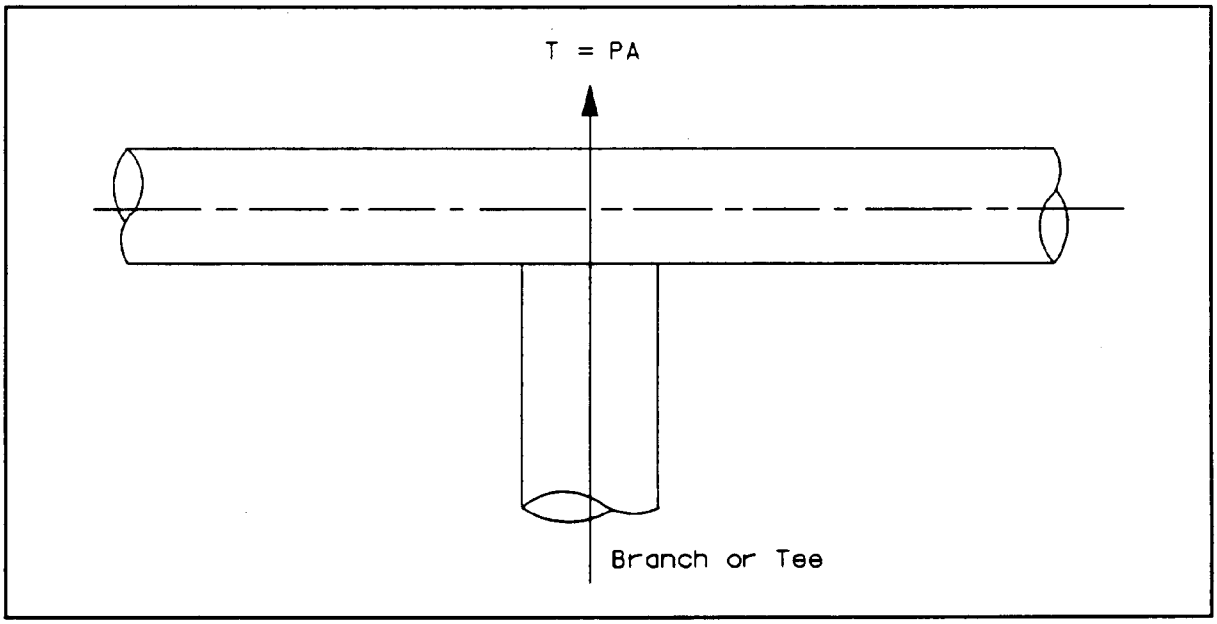

Figure C-5

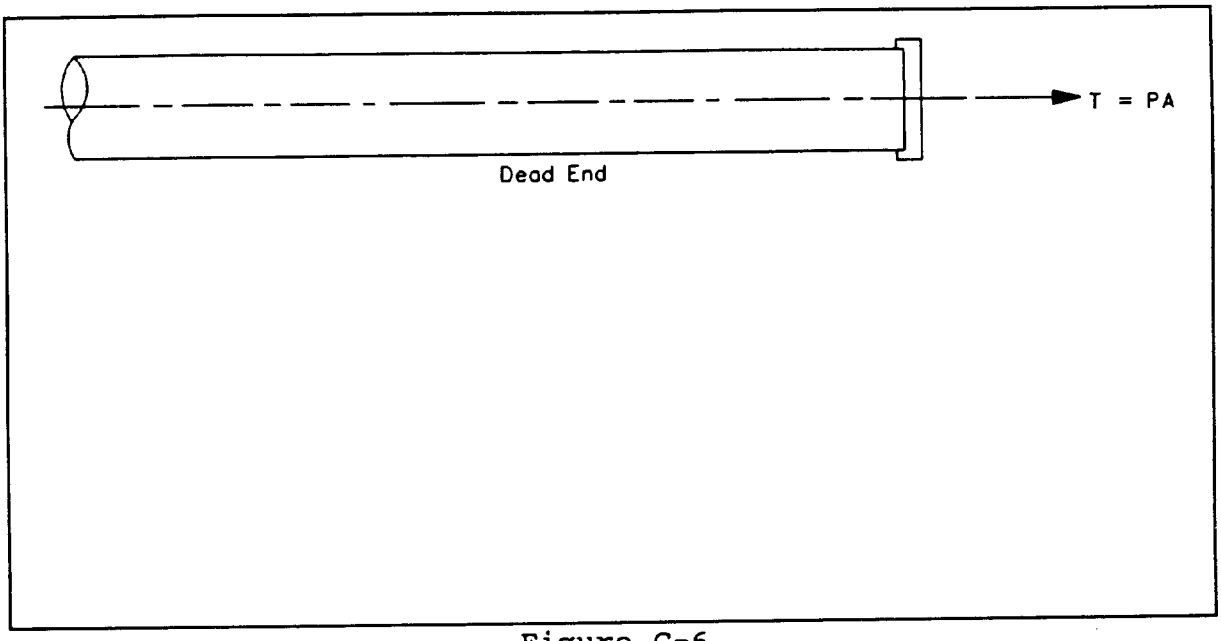

Figure C-6

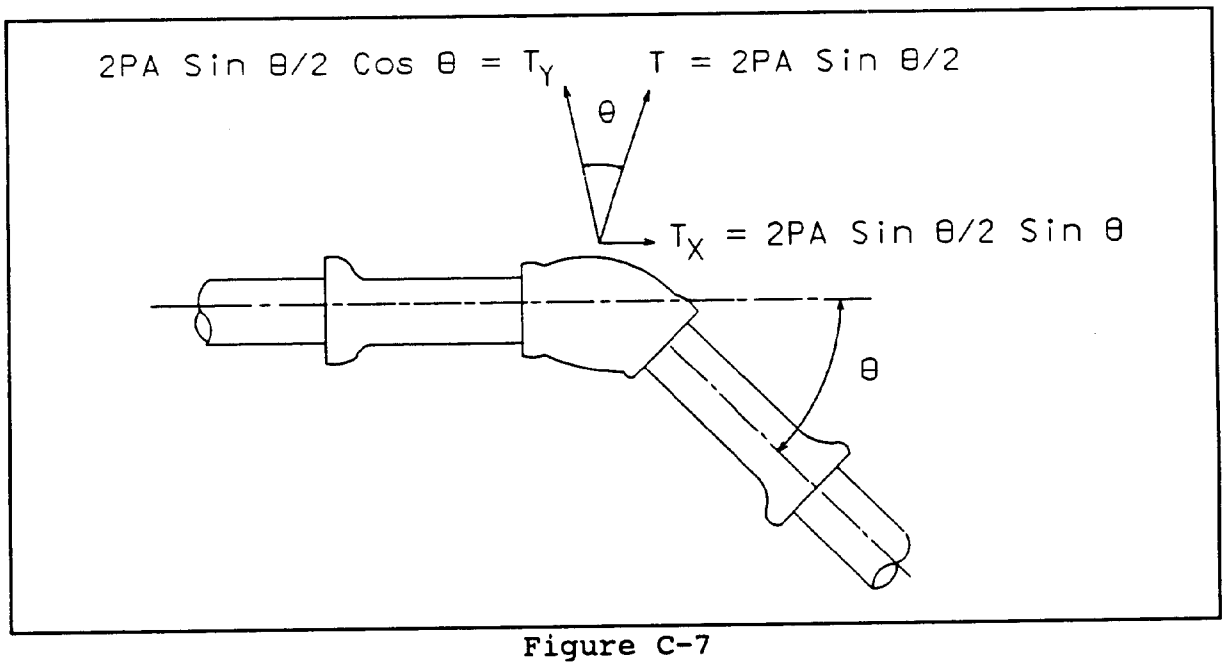

Figure C-7

L = restrained pipe length, one leg,
P = internal pressure of pipe,
A = internal cross—section of pipe,
2 = angle of deflection of bend,
F_f = unit frictional force f(2 W_e + W_p + W_w),
R = reduction factor,
($_s$ = unit weight of soil,
Z = depth of embedment,
K_p = coefficient of passive pressure,
D_o = outer diameter of pipe,
W_e = weight of earth on pipe,
W_p = weight of pipe,
W_w = weight of water in pipe,
f = as defined in paragraph C-3, and
F_s = Factor of Safety.

In the absence of information regarding maximum allowable displacement of pipe and pipe joints, use K_0 instead of RKp. The above formula is then;

$$L \geq F_s(PA \tan 0/2)/F_f + 0.5 (_s Z K_o D_o)$$

where, K_0 = coefficient of at-rest pressure. If movement is permitted, the reduction factor CR) must be determined by a geotechnical engineer.

C-6. Trenching and Backfilling.

Trenching and backfilling is specified in CEGS 02222 to include bedding, if required, initial backfill to at least one foot above pipe, and final backfill to ground surface. This is shown in Figure C-8.

The backfilling, or laying condition as it is sometimes called, has relevance on the reduction factor (R) used to develop the partial passive soil pressure for the restrained joint conditions. Use only cohesionless materials, if at all possible, as bedding, initial backfill, and final backfill.

C-7. Thrust blocks for horizontal bends are shown in Figures C-9, C-10, C—1l and C-12.

C-8. Thrust blocks for vertical bends are shown as follows. For thrust vertically upward see Figures C-13 and C-14, and for thrust vertically downward see Figure C-15.

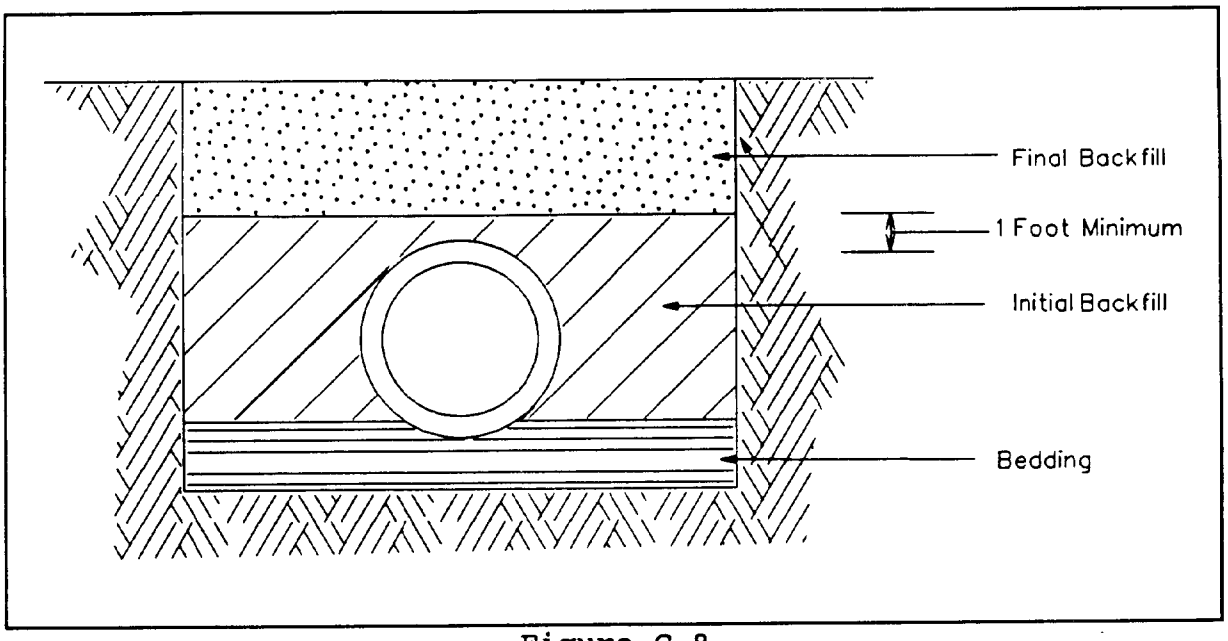

Figure C-8

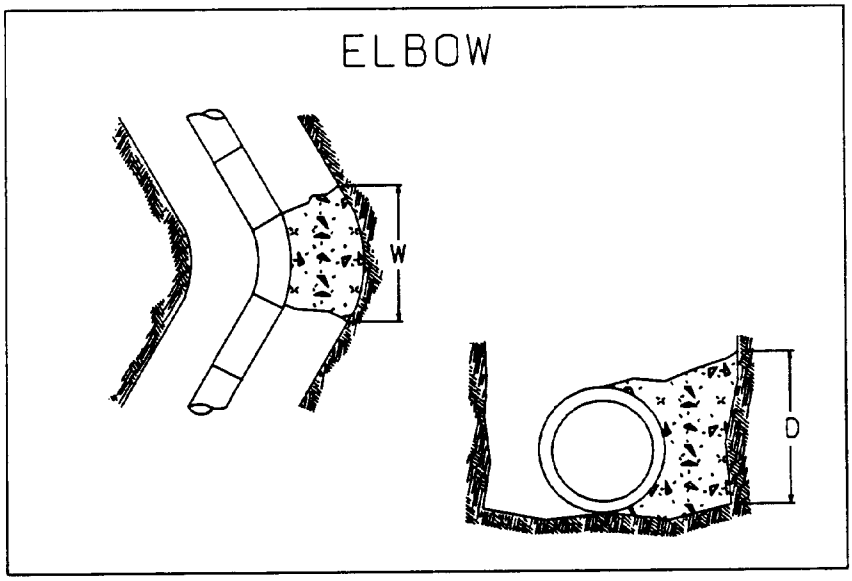

Figure C-9

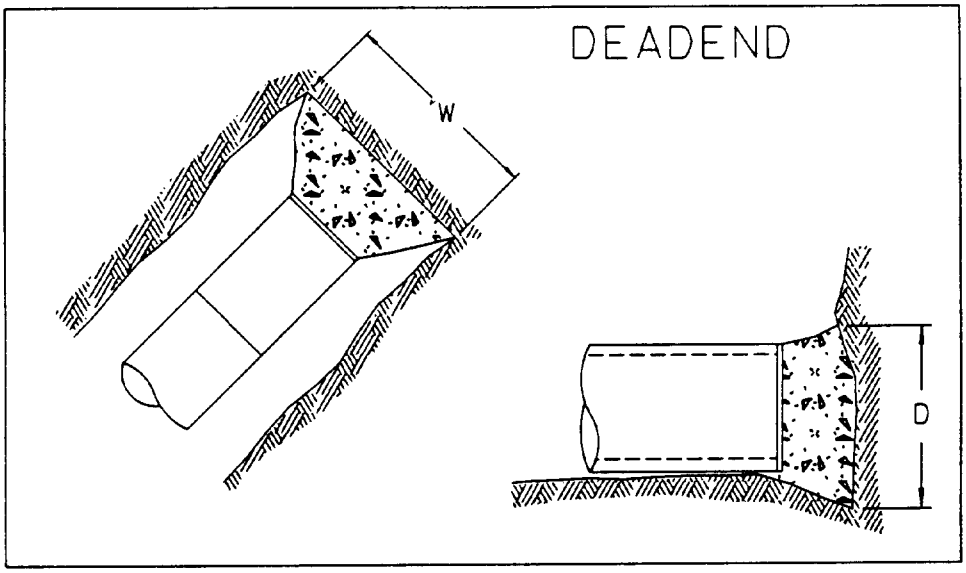

Figure C-10

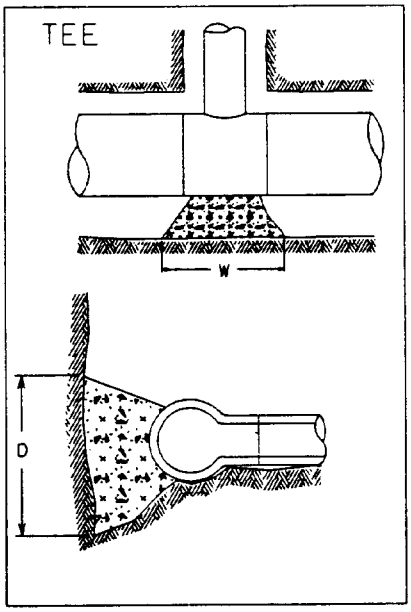

Figure C-11

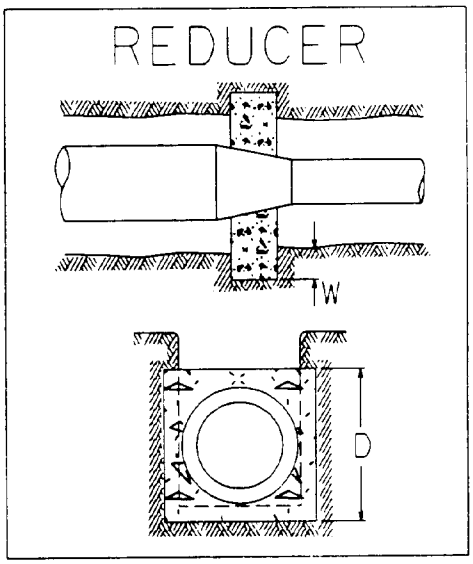

Figure C-12

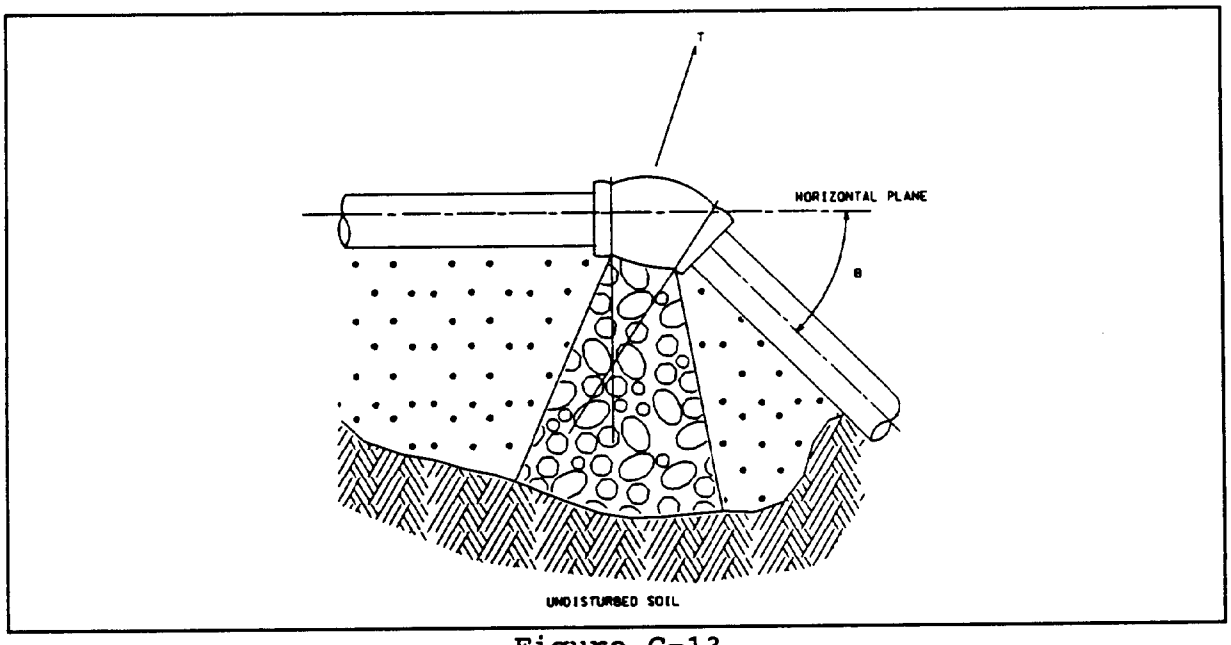

Figure C-13

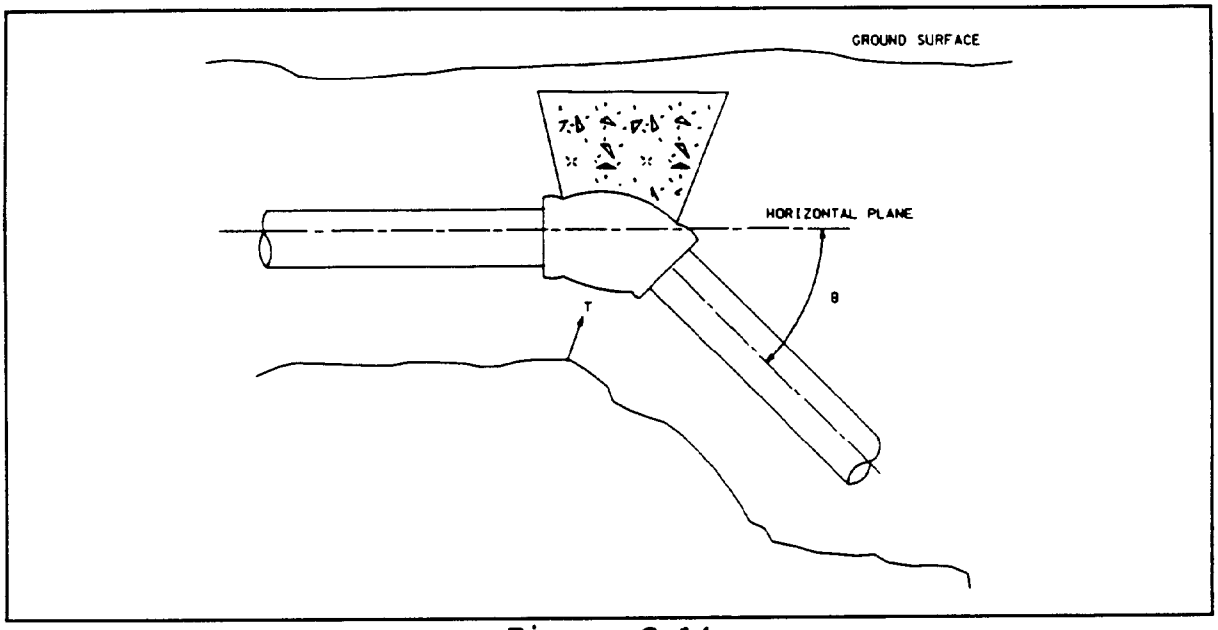

Figure C-14

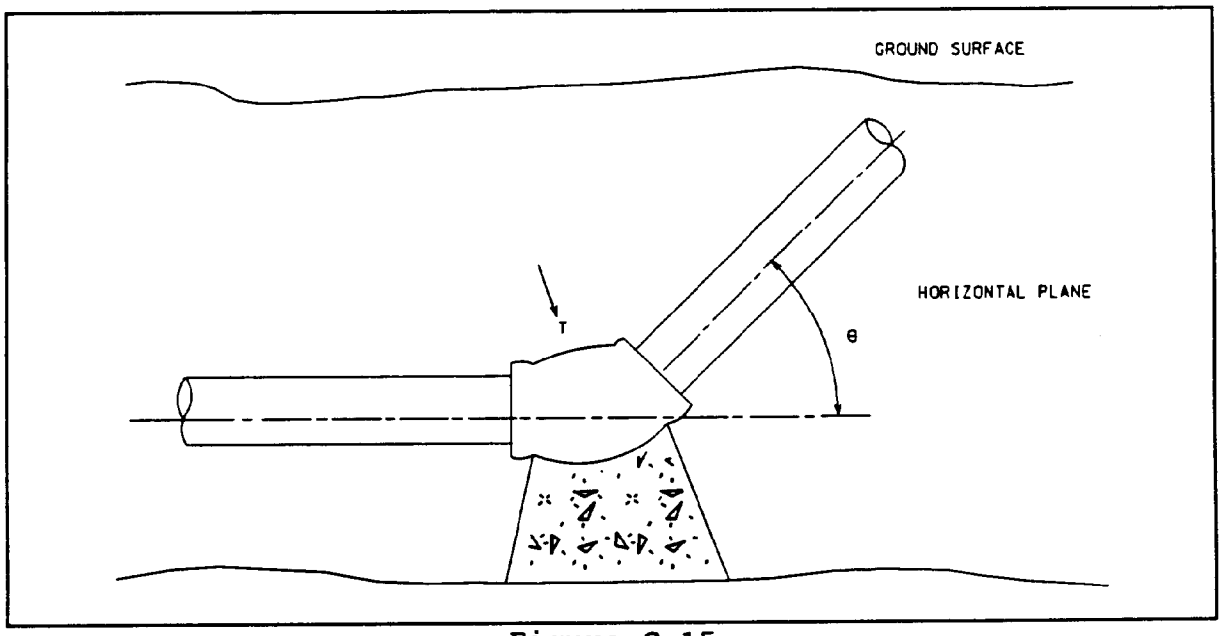

Figure C-15

C-9. Specifications.

C-9.1. CEGS 02222, Excavation, Filling, and Backfilling for Utilities Systems.

Satisfactory materials for all but final backfill should consist of any cohesionless material (i.e., GW, GP, SW, and SP) as classified by ASTM D 2487, Standard Test Method for Classification of Soils for Engineering Purposes. Limit all material to 3 inches or smaller. Unsatisfactory materials should include all and any material not listed as satisfactory. Select granular material should consist of only satisfactory material classified as GW or SW, natural or crushed, or crushed slag.

C—9.2. CEGS 02660, Water Lines.

Incorporate the guidance of this Appendix (i.e., Appendix C) into the paragraphs relating to Thrust Restraint.

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