PDHonline Course C695 (2 PDH)

An Introduction to Drainage Pipe Strength, Cover and Bedding

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(Figures, tables and formulas in this publication may at times be a little difficult to read, but they are the best available. **DO NOT PURCHASE THIS PUBLICATION IF THIS LIMITATION IS NOT ACCEPTABLE TO YOU.)**

1. INTRODUCTION. A drainage pipe is defined as a structure (other than a bridge) to convey water through a trench or under a fill or some other obstruction. Materials for permanent-type installations include non-reinforced concrete, reinforced concrete, corrugated steel, asbestos-cement, clay, corrugated aluminum alloy, and structural plate steel pipe.

2. SELECTION OF TYPE OF PIPE.

a. The selection of a suitable construction conduit will be governed by the availability and suitability of pipe materials for local conditions with due consideration of economic factors. It is desirable to permit alternates so that bids can be received with contractor's options for the different types of pipe suitable for a specific installation. Allowing alternates serves as a means of securing bidding competition. When alternate designs are advantageous, each system will be economically designed, taking advantage of full capacity, best slope, least depth, and proper strength and installation provisions for each material involved. Where field conditions dictate the use of one pipe material in preference to others, the reasons will be clearly presented in the design analysis.

b. Several factors should be considered in selecting the type of pipe to be used in construction. The factors include strength under either maximum or minimum cover being provided, pipe bedding and backfill conditions, anticipated loadings, length of pipe sections, ease of installation, resistance to corrosive action by liquids carried or surrounding soil materials, suitability of jointing methods, provisions for expected deflection without adverse effect on the pipe structure or on the joints or overlying materials, and cost of maintenance. Although it is possible to obtain an acceptable pipe installation to meet design requirements by establishing special provisions for several possible materials, ordinarily only one or two alternates will economically meet the individual requirements for a proposed drainage system.

3. SELECTION OF N VALUES. A designer is continually confronted with what coefficient of roughness n to use in a given situation. The question of whether n should be based on the new and ideal condition of a pipe or on anticipated condition at a later date is difficult to answer. Sedimentation or paved pipe can affect the coefficient of roughness. Tables available in the technical literature give the n values for smooth interior pipe of any size, shape or type and for annular and helical corrugated metal pipe both unpaved and 25 percent paved. When n values other than those listed are selected, such values will be amply justified in the design analysis.

4. RESTRICTED USE OF BITUMINOUS-COATED PIPE. Corrugated-metal pipe with any percentage of bituminous coating will not be installed where solvents can be expected to enter the pipe. Polymeric coated corrugated steel pipe is recommended where solvents might be expected.

5. MINIMUM COVER.

a. In the design and construction of the drainage system it will be necessary to consider both minimum and maximum earth cover allowable on the underground conduits to be placed under both flexible and rigid pavements. Underground conduits are subject to two principal types of loads: dead loads (DL) caused by embankment or trench backfill plus superimposed stationary surface loads, uniform or concentrated; and live or moving loads (LL), including impact. Live loads assume increasing importance with decreasing fill height.

b. AASHTO Standard Specifications for Highway Bridges should be used for all H–20 Highway Loading Analyses. AREA Manual for Railway Engineering should be used for all Cooper's E 80 Railway Loadings. Appropriate pipe manufacturer design manuals should be used for maximum cover analyses.

c. Drainage systems should be designed in order to provide an ultimate capacity sufficient to serve the planned installation, Addition to, or replacement of, drainage lines following initial construction is costly.

d. Investigations of in-place drainage and erosion control facilities at a number of installations were made during the period 1966 to 1972. The facilities observed varied from one to more than 30 years of age. The study revealed that buried conduits and associated storm drainage facilities installed from the early 1940's until the mid-1960's appeared to be in good to excellent structural condition. However, many reported failures of buried conduits occurred during construction. Therefore, it should be noted that minimum conduit cover requirements are not always adequate during construction. When construction equipment, which may be heavier than live loads for which the conduit has been designed, is operated over or near an already inplace underground conduit, it is the responsibility of the contractor to provide any additional cover during construction to avoid damage to the conduit. Major improvements in the design and construction of buried conduits in the two decades mentioned include, among other items, increased strength of buried pipes and conduits, increased compaction requirements, and revised minimum cover tables.

e. The necessary minimum cover in certain instances may determine pipe grades. A safe minimum cover design requires consideration of a number of factors including selection of conduit material, construction conditions and specifications, selection of pavement design, selection of backfill material and compaction, and the method of bedding underground conduits. Emphasis on these factors must be carried from the design stage through the development of final plans and specifications.

f. Tables 1 through 6 identify certain suggested cover requirements for storm drains and culverts which should be considered as guidelines only. Cover requirements have been formulated for asbestos-cement pipe, reinforced and non-reinforced concrete pipe, corrugated-aluminum-alloy pipe, corrugated-steel pipe, structural-plate-aluminum-alloy pipe, and structural-plate-steel pipe. The different sizes and materials of conduit and pipe have been selected to allow the reader an appreciation for the many and varied items which are commercially available for construction purposes. The cover depths listed are suggested only for average bedding and backfill conditions. Deviations from average conditions may result in significant minimum cover requirements and separate cover analyses must be made in each instance of a deviation from average conditions. Specific bedding, backfill and trench widths may be required in certain loca-tions; each condition deviating from the average condition should be analyzed separately. Where warranted by design analysis the suggested maximum cover may be exceeded.

Diameter in.	Suggested Maximum Cover Above Top of Pipe, ft				
	Circular Section				
	Class				
	1500	2000	2500	9000	3750
12	9	13	16	19	24
15	10	13	17	19	24
18	10	13	17	20	25
21	10	13	17	20	25
24	10	14	17	20	25
27	10	14	17	20	25
30	11	14	17	21	24
33	11	14	17	21	26
36	11	14	17	21	26
42	11	14	17	21	26

U.S. Army Corps of Engineers

Notes:

1. The suggested values shown are for average conditions and are to be considered as guidelines only for dead load plus H–20 live load.
2. Soil conditions. trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
3. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H-20 live loads. Cooper E–80 ; railway loadings should be independently made.
4. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
5. Calculations to determine maximum cover for Cooper E–80 railway loadings are measured from the bottom of the tie to the top of the pipe.
6. The number in the class designation for asbestos-cement pipe is the minimum 3-edge test load to produce failure in pounds per linear foot. It is independent of pipe diameter. An equivalent to the D-load can be obtained by dividing the number in the class designation by the internal pipe diameter in feet.
7. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards then cover depths may be adjusted accordingly.
8. See table C–9 for suggested minimum cover requirements.

Table 1

Suggested maximum cover requirements for asbestos cement pipe H-20 highway loading

Diameter in.	Suggested Maximum Cover Above Top of Pipe, ft., Circular Section, Class				
	1200-D	*1500-D*	*2000-D*	*3000-D*	*3750-D*
12		8	15		
24		10	16	46	
36		10	16	34	
48		10	16	29	47
60	9	10	16	27	40
72	8	11	16	26	37
84	9	11	15	25	
108	10	12	15		

Non-Reinforced Concrete

Diameter in.	Suggested Maximum Cover Above Top of Pipe, ft. Circular Section		
	I	II	III
12	14	14	17
24	13	13	14
36	9	12	12

Notes:

1. The suggested values shown are for average conditions and are to be considered as guidelines only for dead load plus H-20 live load.
2. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
3. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H-20 live loads. Cooper E-80 railway loadings should be independently made.
4. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
5. Calculations to determine maximum cover for Cooper E-80 railway loadings are measured from the bottom of the tie to the top of the pipe.
6. "D" loads listed for the various classes of reinforced-concrete pipe are the minimum required 3-edge test loads to produce ultimate failure in pounds per linear foot of interval pipe diameter.
7. Each diameter pipe in each class designation of non-reinforced concrete has a different D-load value which increases with wall thickness.
8. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards, then cover depths may be adjusted accordingly.
9. See table C-9 for suggested minimum cover requirements.

Table 2

Suggested maximum cover requirements for concrete pipe,

reinforced concrete, H-20 highway loading

6. CLASSES OF BEDDING AND INSTALLATION. Figures 1 through 5 indicate the classes of bedding for conduits. Figure 6 is a schematic representation of the subdivision of classes of conduit installation which influences loads on underground conduits.

Diameter in.	Suggested Maximum Cover Above Top of Pipe, ft									
	Circular Section					Vertically Elongated Section				
	Thickness, in.					Thickness, in.				
	.060	.075	.105	.135	.164	.060	.075	.105	.135	.164
12	50	50	86	90	93					
15	40	40	69	72	74					
18	33	33	57	60	62					
24	25	25	43	45	46					
30	20	20	34	36	37					
36	16	16	28	30	31					
42	16	16	28	30	31			50	52	53
48			28	30	31			43	45	47
54			28	30	31					
60				30	31					
66					31					
72					31					

Notes:

1. Corrugated-aluminum-alloy pipe will conform to the requirements of Federal Specification W W-P-402.
2. The suggested values shown are for average conditions and are to be considered as guidelines only for dead load plus H-20 live load Cooper E-80 railway loadings should be independently made.
3. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
4. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H-20 live loads.
5. Cover depths are measured *from* the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
6. Calculations to determine maximum cover for Cooper E-80 railway loadings are measured from the bottom of the tie to the top of the pipe.
7. Vertical elongation will be accomplished by shop fabrication and will generally be 5 % of the pipe diameter.
8. See table C-9 for suggested minium cover requirements.

Table 3

Suggested maximum cover requirements for corrugated aluminum alloy pipe, riveted, helical or welded, fabrication 2-2/3 inch spacing, ½ inch deep corrugations, H-20 highway loading

7. STRENGTH OF PIPE. Pipe shall be considered of ample strength when it meets the conditions specified for the loads indicated in tables 1 through 8. When railway or vehicular wheel loads or loads due to heavy construction equipment (live loads, LL) impose heavier loads, or when the earth (or dead loads, DL) vary materially from those normally encountered, these tables cannot be used for pipe installation design and separate analyses must be made. The suggested minimum and maximum cover shown in the tables pertain to pipe installations in which the back fill material is compacted to at least 90 percent of CE55 (MIL-STD-621) or AASHTO-T99 density (100 percent for cohesionless sands and gravels). This does not modify requirements for any greater degree of compaction specified for other reasons. It is emphasized that proper bedding, backfilling, compaction, and prevention of infiltration of backfill material into pipe are important not only to the pipe, but also to protect overlying and nearby structures. When in doubt about minimum and maximum cover for local conditions, a separate cover analysis must be performed.

8. RIGID PIPE. Tables 1 and 2 indicate maximum and minimum cover for trench conduits employing asbestos-cement pipe and concrete pipe. If positive projecting conduits are employed they are those which are installed in shallow bedding with a part of the conduit projecting above the surface of the natural ground and then covered with an embankment. Due allowance will be made in amounts of minimum and maximum cover for positive projecting conduits. Table 9 suggests guidelines for minimum cover to protect the pipe during construction and the minimum finished height of cover.

9. FLEXIBLE PIPE. Suggested maximum cover for trench and positive projecting conduits are indicated in tables 3 through 6 for corrugated aluminum-alloy pipe, corrugated-steel pipe, structural-plate-aluminum-alloy pipe, and structural plate- steel pipe. Conditions other than those stated in the tables, particularly other loading conditions will be compensated for as necessary. For unusual installation conditions, a detailed analysis will be made so that ample safeguards for the pipe will be provided with regard to strength and resistance to deflection due to loads. Determinations for deflections of flexible pipe should be made if necessary. For heavy live loads and heavy loads due to considerable depth of cover, it is desirable that a selected material, preferably bank-run gravel or crushed stone where economically available, be used for backfill adjacent to the pipe. Table 9 suggests guidelines for minimum cover to protect the pipe during construction and the minimum finished height of cover.

1O. BEDDING OF PIPE (CULVERTS AND STORM DRAINS). The contact between a pipe and the foundation on which it rests is the pipe bedding. It has an important influence on the supporting strength of the pipe. For drainpipes at military installations, the method of bedding shown in figure 3 is generally satisfactory for both trench and positive projecting (embankment) installations. Some designs standardize and classify various types of bedding in regard to the shaping of the foundation, use of granular material, use of concrete, and similar special requirements. Although such refinement is not considered necessary, at least for standardized cover requirements, select, fine granular material can be used as an aid in shaping the bedding, particularly where foundation conditions are difficult. Also, where economically available, granular materials can be used to good advantage for backfill adjacent to the pipe. When culverts or storm drains are to be installed in unstable or yielding soils, under great heights of fill, or where pipe will be subjected to very heavy live loads, a method of bedding can be used in which the pipe is set in plain or reinforced concrete of suitable thickness extending upward on each side of the pipe. In some instances, the pipe may be totally encased in concrete or concrete may be placed along the side and over the top of the pipe (top or arch encasement) after proper bedding and partial backfilling. Pipe manufacturers will be helpful in recommending type and specific requirements for encased, partially encased, or specially reinforced pipe in connection with design for complex conditions.

MAXIMUM COVER ABOVE TOP OF PIPE, FEET

DIAMETER, INCHES	.052	RIVETED - THICKNESS, INCHES .064	.079	.109	.138	.168	.052	HELICAL - THICKNESS, INCHES .064	.079	.109	.138	.168
12	92	92	101	130			170	213	266	372		
15	74	74	80	104			136	170	212	298		
18	61	61	67	86			113	142	173	212		
21	53	53	57	74			97	121	139	164		
24	46	46	50	65	68		85	106	120	137	155	
27	41	41	44	57	60		75	94	103	120	133	
30	37	37	40	52	54		68	85	101	110	119	
36	30	31	33	43	45		56	71	88	98	103	
42	34	34	47	74	77	81	48	60	76	82	95	99
48		30	41	65	68	71		53	66	88	91	93
54			36	57	60	63			59	82	88	90
60				52	54	57				74	86	87
66					49	51					85	86
72					45	47					79	85
78						43						84
84						40						75

Table 4

Suggested maximum cover requirements for corrugated steel pipe, 2-2/3 inch spacing, ½ inch deep corrugations, H-20 highway loading

Diameter, in.	Suggested Maximum Cover Above Top of Pipe, ft						
	Circular Section						
	Thickness, in.						
	0.10	0.125	0.15	0.175	0.20	0.225	0.250
72	24	32	41	48	55	61	64
84	20	27	35	41	47	52	55
96	18	24	30	36	41	45	50
108	16	21	27	32	37	40	44
120	14	19	24	29	33	36	40
132	13	17	22	26	30	33	36
144	12	16	20	24	27	30	33
156		14	18	22	25	28	30
168		13	17	20	23	26	28
180			16	19	22	24	26

U.S. Army Corps of Engineers

Notes:

1. Structural-plate-aluminum-alloy pipe will conform to the requirements of Federal Specification WW–P–402.
2. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
3. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H–20 live loads. Cooper E-80 railway loadings should be independently made.
4. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
5. Calculations to determine maximum cover for Cooper E–80 railway loadings are measured from the bottom of the tie to the top of the pipe.
6. The number in the class designation for asbestos-cement pipe is the minimum 3-edge test load to produce failure in pounds per linear foot. It is independent of pipe diameter. An equivalent to the D-load can be obtained by dividing the number in the class designation by the internal pipe diameter in feet.
7. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards then cover depths may be adjusted accordingly.
8. See table C-9 for suggested minimum cover requirements.

Table 5

Suggested Maximum Cover Requirements for Structural-Plate-Aluminum-Alloy Pipe, 9-Inch Spacing, 2 1/2-Inch Corrugations

H–20 Highway Loading

Diameter, inches	Maximum cover above top of pipe, feet				
	Helical—thickness, inches				
	.064	.079	.109	.138	.168
48	54	68	95	122	132
54	48	60	84	109	117
60	43	54	76	98	107
66	39	49	69	89	101
72	36	45	63	81	96
78	33	41	58	75	92
84	31	38	54	70	85
90	29	36	50	65	80
96		34	47	61	75
102		32	44	57	70
108			42	54	66
114			40	51	63
120			38	49	60

Notes:

1. Corrugated steel pipe will conform to the requirements of Federal Specification WW-P-405.
2. The suggested maximum heights of cover shown in the table are calculated on the basis of the current AASHTO Standard Specifications for Highway Bridges and are based on circular pipe.
3. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
4. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H-20 live loads. Cooper E-80 railway loadings should be independently made.
5. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
6. Calculations to determine maximum cover for Cooper E-80 railway loadings are measured from the bottom of the tie to the top of the pipe.
7. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards then cover depths may be adjusted accordingly.
8. See table C-9 for suggested minimum cover requirements.

Table 6

Suggested Maximum Cover Requirements for Corrugated Steel Pipe,

125-mm Span, 25-mm Deep Corrugations

H–20 Highway Loading

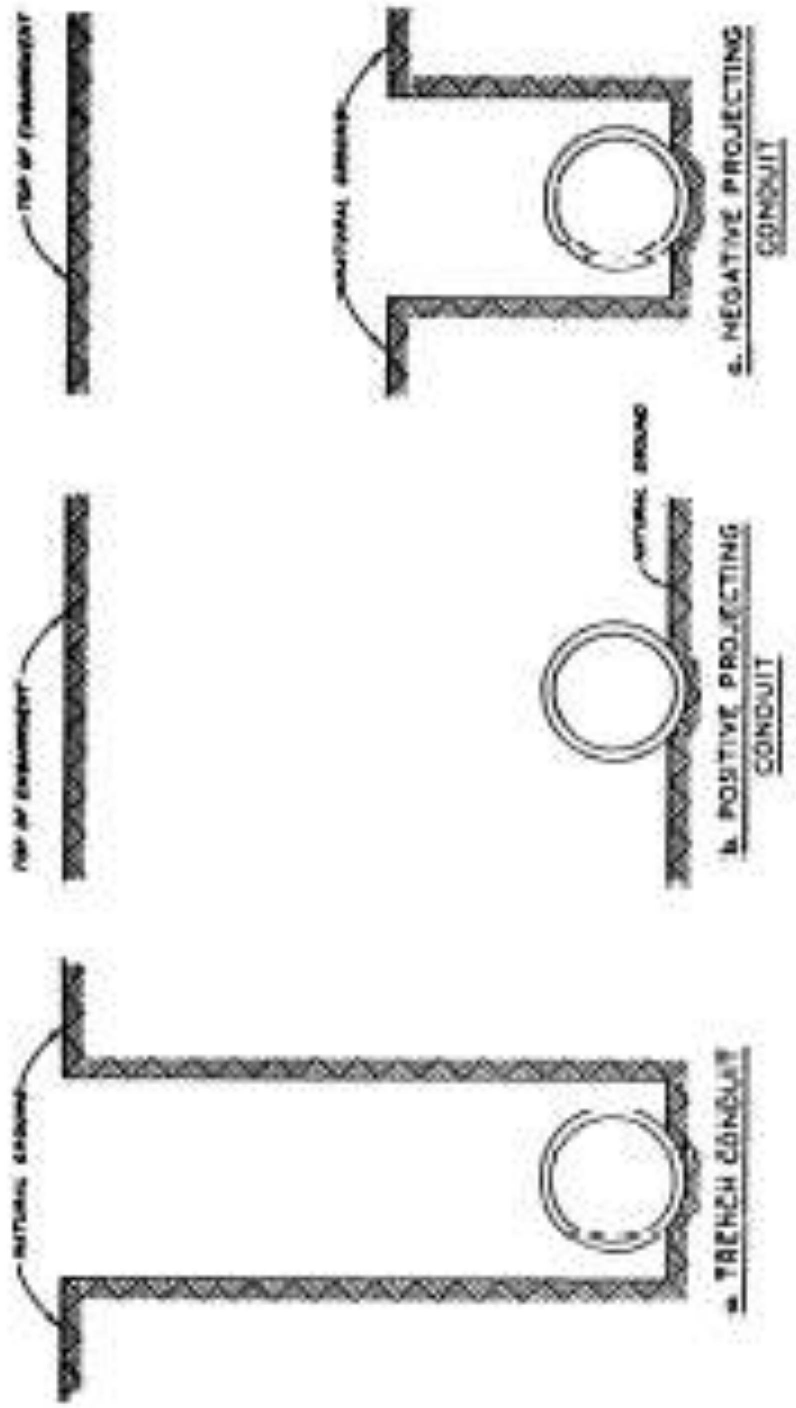

Figure 1

Three main classes of conduits

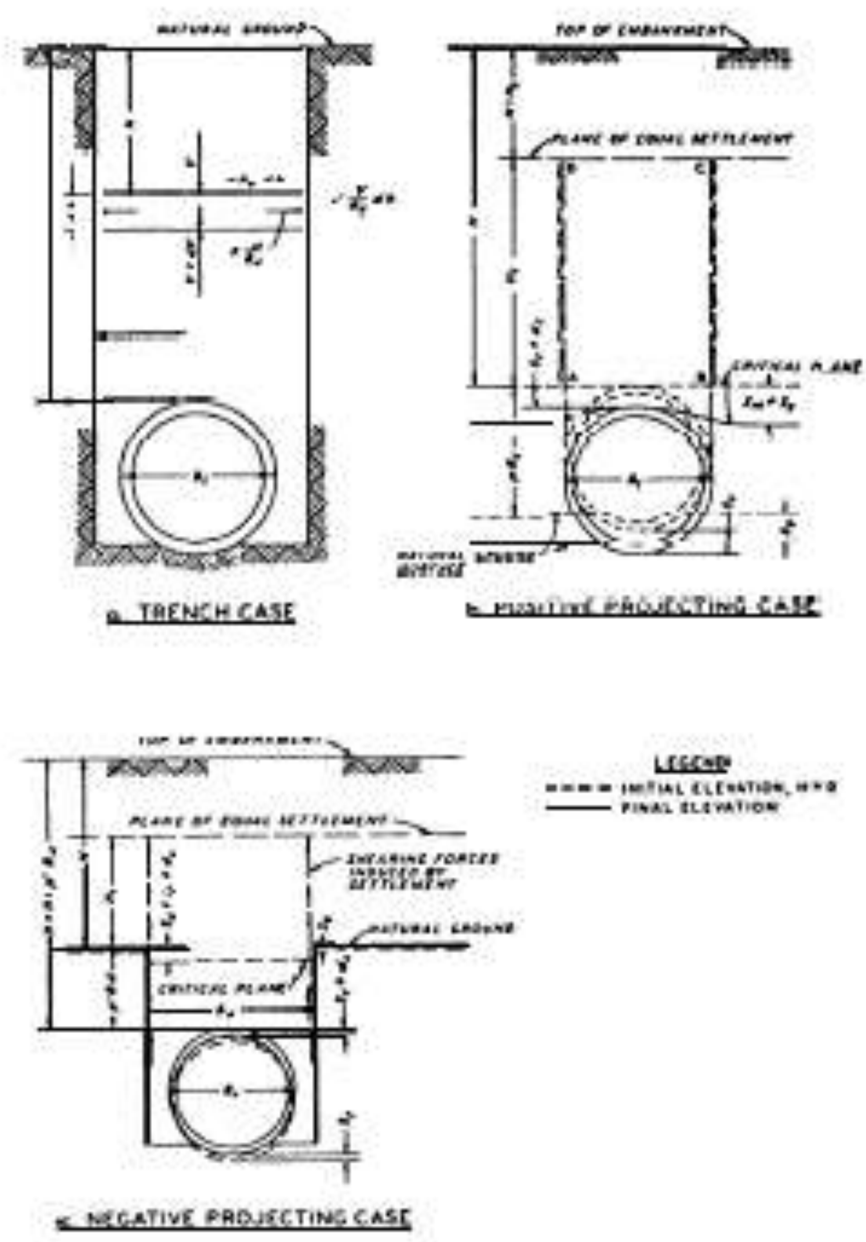

Figure 2

Free-body conduit diagrams

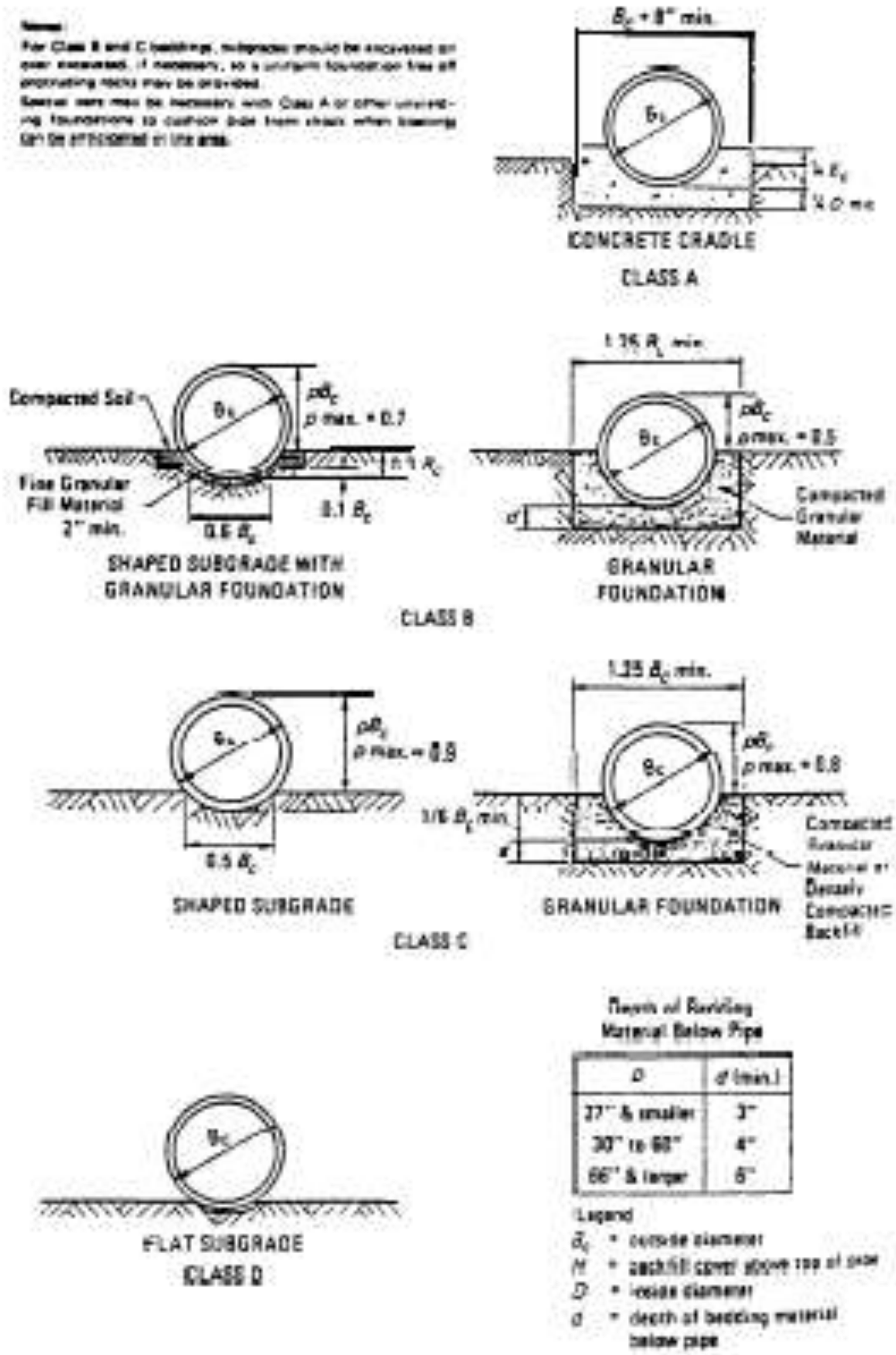

Figure 3

Embankment Beddings Circular Pipe

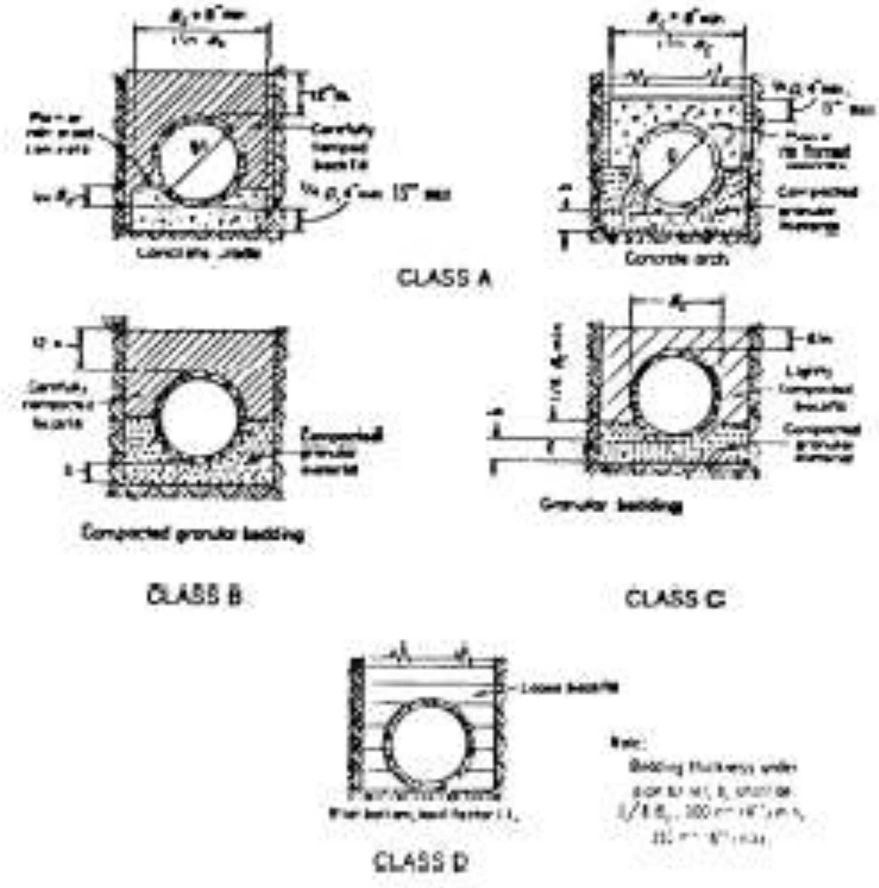

Figure 4

Trench Beddings for Circular Pipe

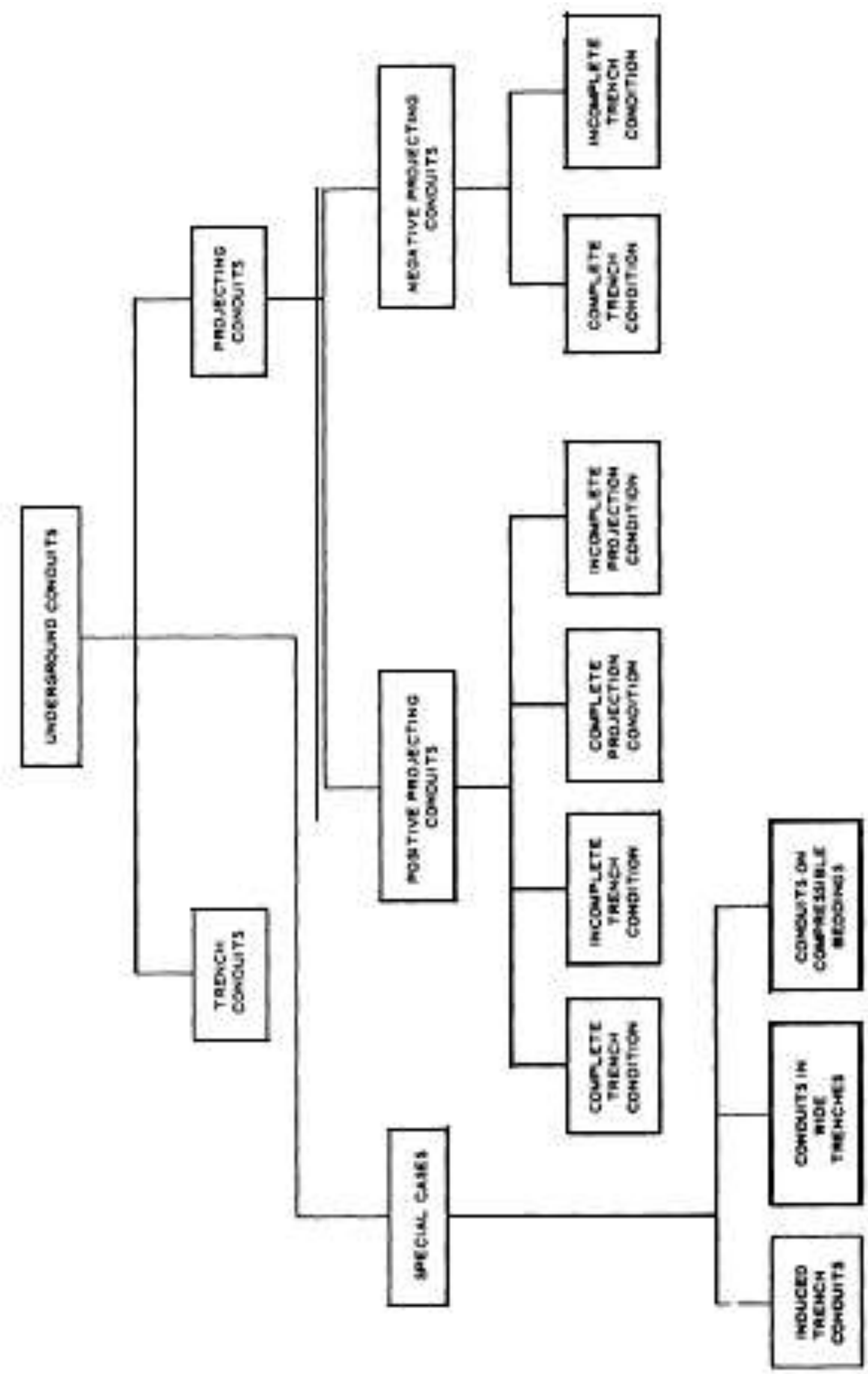
UNDERGROUND CONDUITS
PROJECTING CONDUITS
TRENCH CONDUITS
SPECIAL CASES
NEGATIVE PROJECTING CONDUITS
POSITIVE PROJECTING CONDUITS
INCOMPLETE TRENCH CONDITION
COMPLETE TRENCH CONDITION
INCOMPLETE PROJECTION CONDITION
COMPLETE PROJECTION CONDITION
INCOMPLETE TRENCH CONDITION
COMPLETE TRENCH CONDITION
CONDUITS ON COMPRESSIBLE BEDDINGS
CONDUITS IN WIDE TRENCHES
INDUCED TRENCH CONDUITS

Figure X

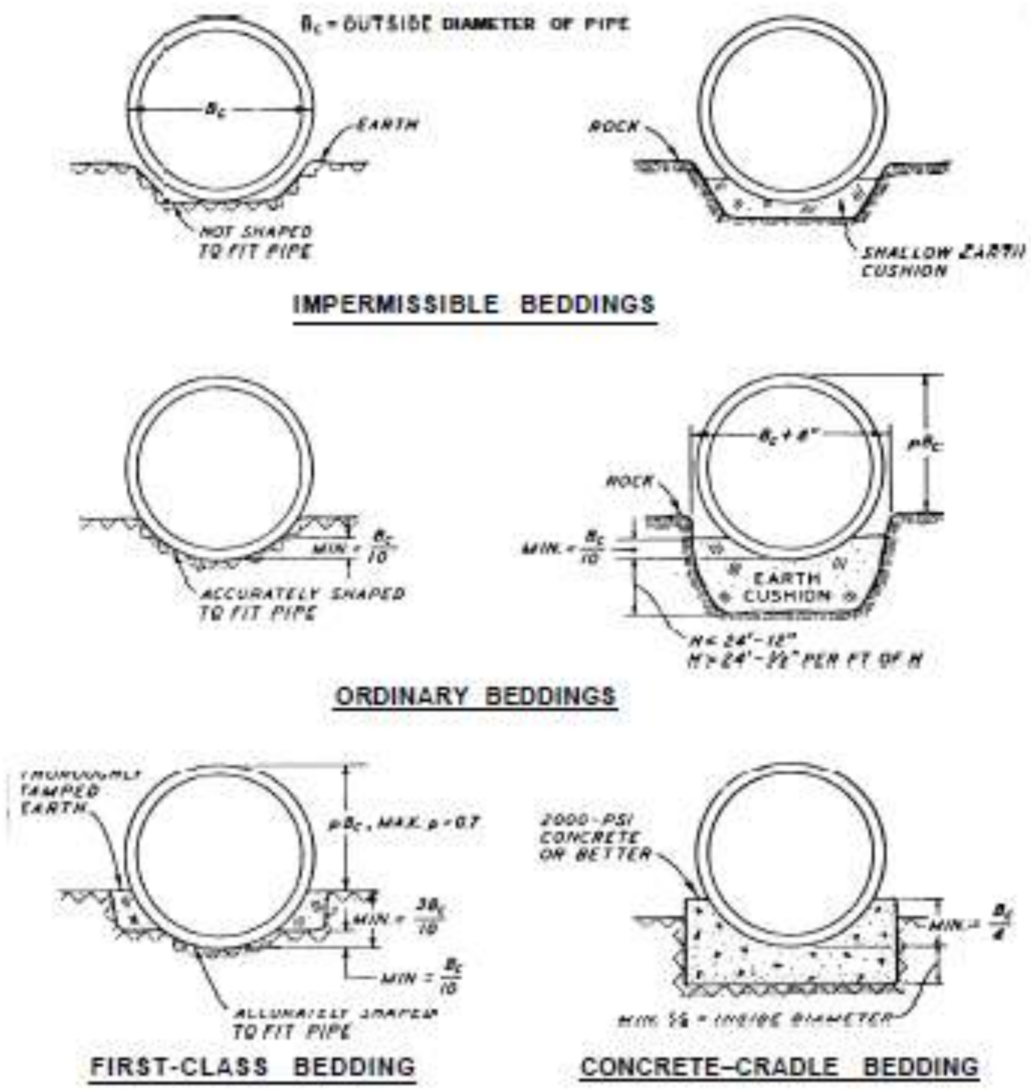

Figure 6

Installation conditions which influence loads on underground conduits

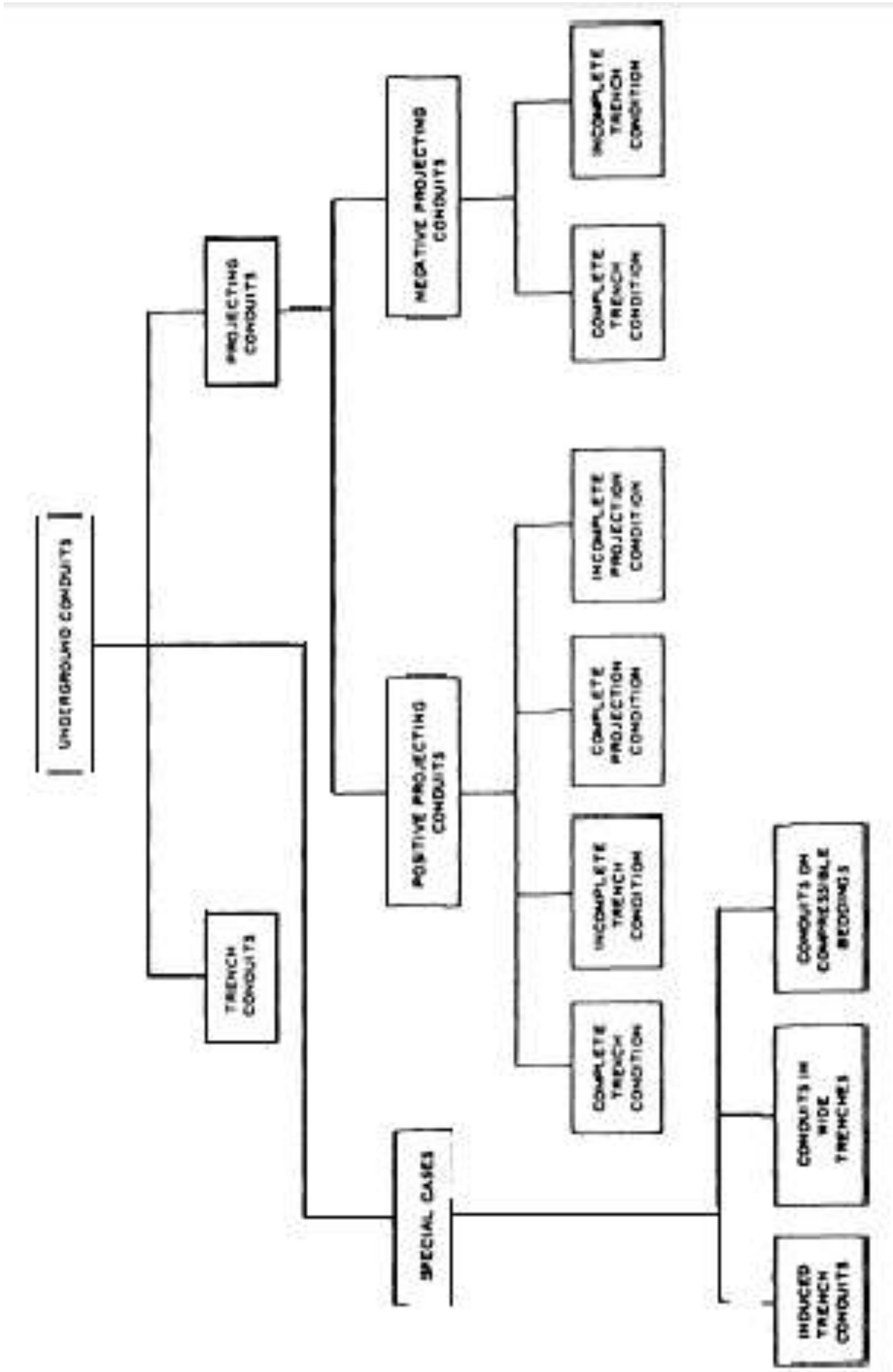

Figure Y

Beddings for positive projecting conduits

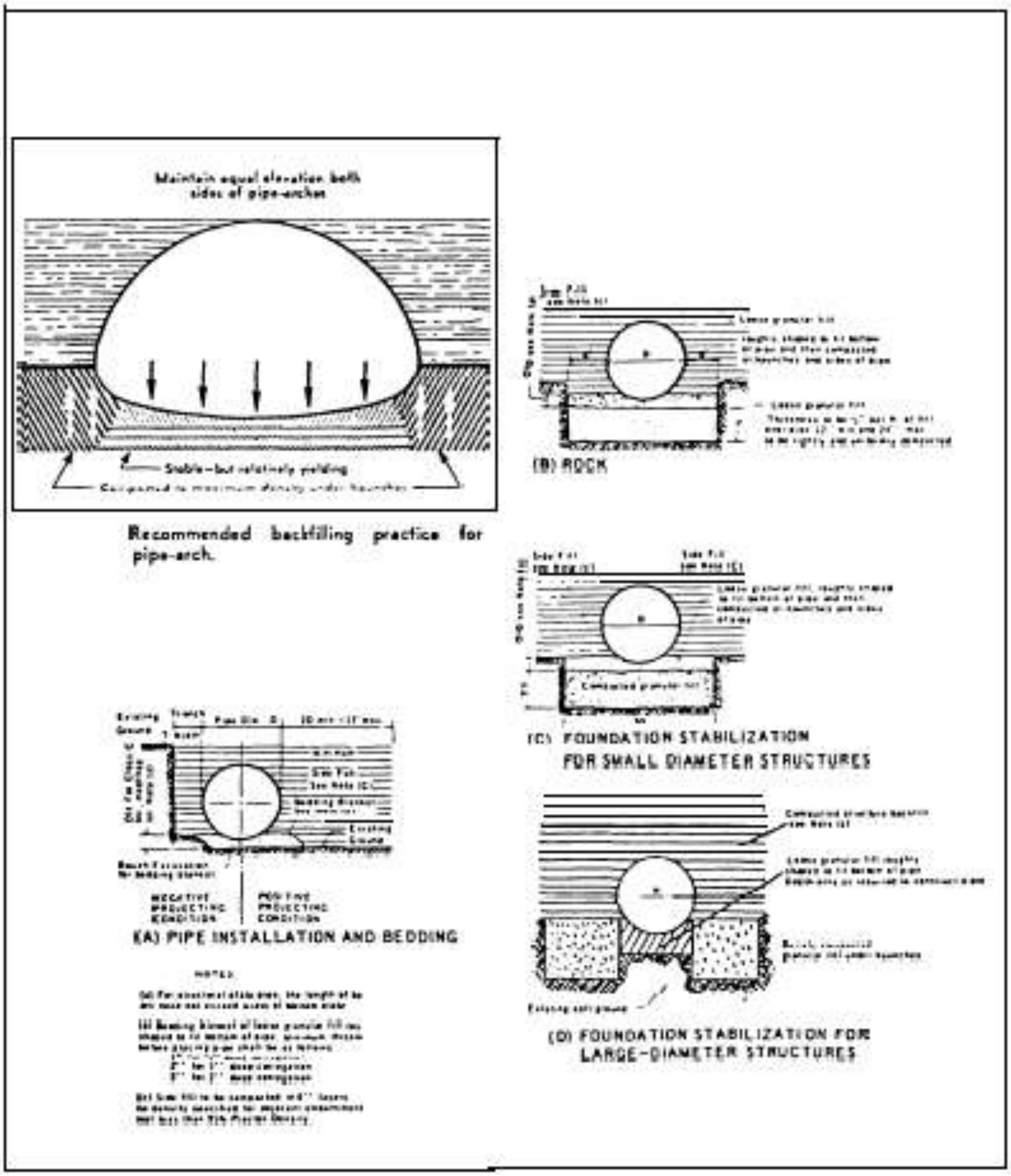

Figure Z

Flexible pipe bedding and installation

MAXIMUM COVER ABOVE TOP OF PIPE, FEET

DIAMETER, FEET	THICKNESS, INCHES .109	.138	.168	.188	.218	.249	.280
5.0	46	68	90	103	124	146	160
5.5	42	62	81	93	113	133	145
6.0	38	57	75	86	103	122	133
6.5	35	52	69	79	95	112	123
7.0	33	49	64	73	88	104	114
7.5	31	45	60	68	82	97	106
8.0	29	43	56	64	77	91	100
8.5	27	40	52	60	73	86	94
9.0	25	38	50	57	69	81	88
9.5	24	36	47	54	65	77	84
10.0	23	34	45	51	62	73	80
10.5	22	32	42	49	59	69	76
11.0	21	31	40	46	56	66	72
11.5	20	29	39	44	54	63	69
12.0	19	28	37	43	51	61	66
12.5	18	27	36	41	49	58	64
13.0	17	26	34	39	47	56	61
13.5	17	25	33	38	46	54	59
14.0	16	24	32	36	44	52	57
14.5	16	23	31	35	42	50	55
15.0	15	22	30	34	41	48	53
15.5	15	22	29	33	40	47	51
16.0		21	28	32	38	45	50
16.5		20	27	31	37	44	48
17.0		20	26	30	36	43	47
17.5		19	25	29	35	41	45
18.0			25	28	34	40	44
18.5			24	27	33	39	43
19.0			23	27	32	38	42
19.5			23	26	31	37	41
20.0				25	31	36	40
20.5				25	30	35	39
21.0					29	34	38
21.5					28	34	37
22.0					28	33	36
22.5					27	32	35
23.0						31	34
23.5						31	34
24.0						30	33
24.5							32
25.0							32
25.5							31

Table 7

Suggested Maximum Cover Requirements for Structural Plate Steel Pipe, 6-Inch Span, 2-Inch Deep Corrugations

NOTES

1. Corrugated steel pipe will conform to the requirements of Federal Specification W–P–405.
2. The suggested maximum heights of cover shown in the table are calculated on the basis of the current AASHTO Standard Specifications for Highway Bridges and are based on circular pipe.
3. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas. --
4. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying roads, streets and open storage areas subject to H–20 live loads. Cooper E–80 railway loadings should be independently made.
5. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
6. Calculations to determine maximum cover for Cooper E-80 railway loadings are measured from the bottom of the tie to the top of the pipe.
7. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards then cover depths may be adjusted accordingly.
8. See table 9 for suggested minimum cover requirements.

MAXIMUM COVER ABOVE TOP OF PIPE, FEET

DIAMETER, INCHES	RIVETED - THICKNESS, INCHES .064	.079	.109	.138	.168	HELICAL - THICKNESS, INCHES .064	.079	.109	.138	.168
36	53	66	98	117	130	81	101	142	178	201
42	45	56	84	101	112	69	87	122	142	157
48	39	49	73	88	98	61	76	107	122	132
54	35	44	65	78	87	54	67	95	110	117
60	31	39	58	70	78	48	61	85	102	107
66	28	36	53	64	71	44	55	77	97	101
72	26	33	49	58	65	40	50	71	92	96
78	24	30	45	54	60	37	47	65	84	93
84	22	28	42	50	56	34	43	61	78	91
90	21	26	39	47	52	32	40	57	73	89
96		24	36	44	49		38	53	69	84
102		23	34	41	46		35	50	64	79
108			32	39	43			47	61	75
114			30	37	41			45	58	71
120			29	35	39			42	55	67

Table 8

Suggested Maximum Cover Requirements for Corrugated Steel Pipe,

3-Inch Span, 1-Inch Corrugations, H-20 Highway Loading

NOTES:
1. Corrugated steel pipe will conform to there requirements of Federal Specification WW-P-4O5.
2. The suggested maximum heights of cover shown in the table are calculated on the basis of the current AASHTO Standard Specifications for Highway Bridges and are based on circular pipe.
3. Soil conditions, trench width and bedding conditions vary widely throughout varying climatic and geographical areas.
4. Calculations to determine maximum cover should be made for all individual pipe and culvert installations underlying
roads, streets and open storage areas subject to H–20 live loads. Cooper E–80 railway loadings should be independently made.
5. Cover depths are measured from the bottom of the subbase of pavements, or the top of unsurfaced areas, to top of pipe.
6. Calculations to determine maximum cover for Cooper E–80 railway loadings are measured from the bottom of the tie to the top of the pipe.
7. If pipe produced by a manufacturer exceeds the strength requirements established by indicated standards then cover depths may be adjusted accordingly.
8. See table 9 for suggested minimum cover requirements.

	Minimum Cover to Protect Pipe		
	Pipe Diameter, in.	Height of Cover During Construction ft.	Minimum Finished Height of Cover (From Bottom of Subbase, to Top of Pipe)
Asbestos-Cement Pipe	12" to 42"	Diameter/2 or 3.0' whichever is greater	Diameter/2 or 2.0' whichever is greater
Concrete Pipe Reinforced	12" to 108"	Diameter/2 or 3.0' whichever is greater	Diameter/2 or 2.0' whichever is greater
Non-Reinforced	12" to 36"	Diameter/2 or 3.0' whichever is greater	Diameter/2 or 3.0' whichever is greater
Corrugated Aluminum Pipe 2-2/3" x 1/2"	12" to 24" 30" and over	1.5' Diameter	Diameter/2 or 1.0' whichever is greater Diameter/2
Corrugated Steel Pipe 3" x 1"	12" to 30" 36" and over	1.5' Diameter	Diameter/2 or 1.0' whichever is greater Diameter/2
Structural Plate Aluminum Alloy Pipe 9" x 2-1/2"	72" and over	Diameter/2	Diameter/4
Structural Plate Steel 6" x 2"	60" and over	Diameter/2	Diameter/4

Table 9

Suggested Guidelines for Minimum Cover

H-20 Highway Loading

NOTES:
1. All values shown above are for average conditions and are to be considered as guidelines only.
2. Calculations should be made for minimum cover for all individual pipe installations for pipe underlying roads, streets and open storage areas subject to H–20 1ive loads.
3. Calculations for minimum cover for all individual pipe installations should be separately made for all Cooper E–80 railroad live loading.
4. In seasonal frost areas, minimum pipe cover must meet requirements of table 2–3 of TM 5–820-3 for protection of storm drains.
5. Pipe placed under rigid pavement will have minimum cover from the bottom of the subbase to top of pipe of I.O ft. For pipe up to 60 inches and greater than I. Oft. for sizes above 60 inches if calculations so indicate.
6. Trench widths depend upon varying conditions of construction but maybe as wide as is consistent with space required to install the pipe and as deep as can be managed from practical construction methods.
7. Non-reinforced concrete pipe is available in sizes up to 36 inches.
8. See tables 1 through 8 for suggested maximum cover requirements.