2020
Second Edition
AWWA M55
HDPE Pipe

Amster Howard
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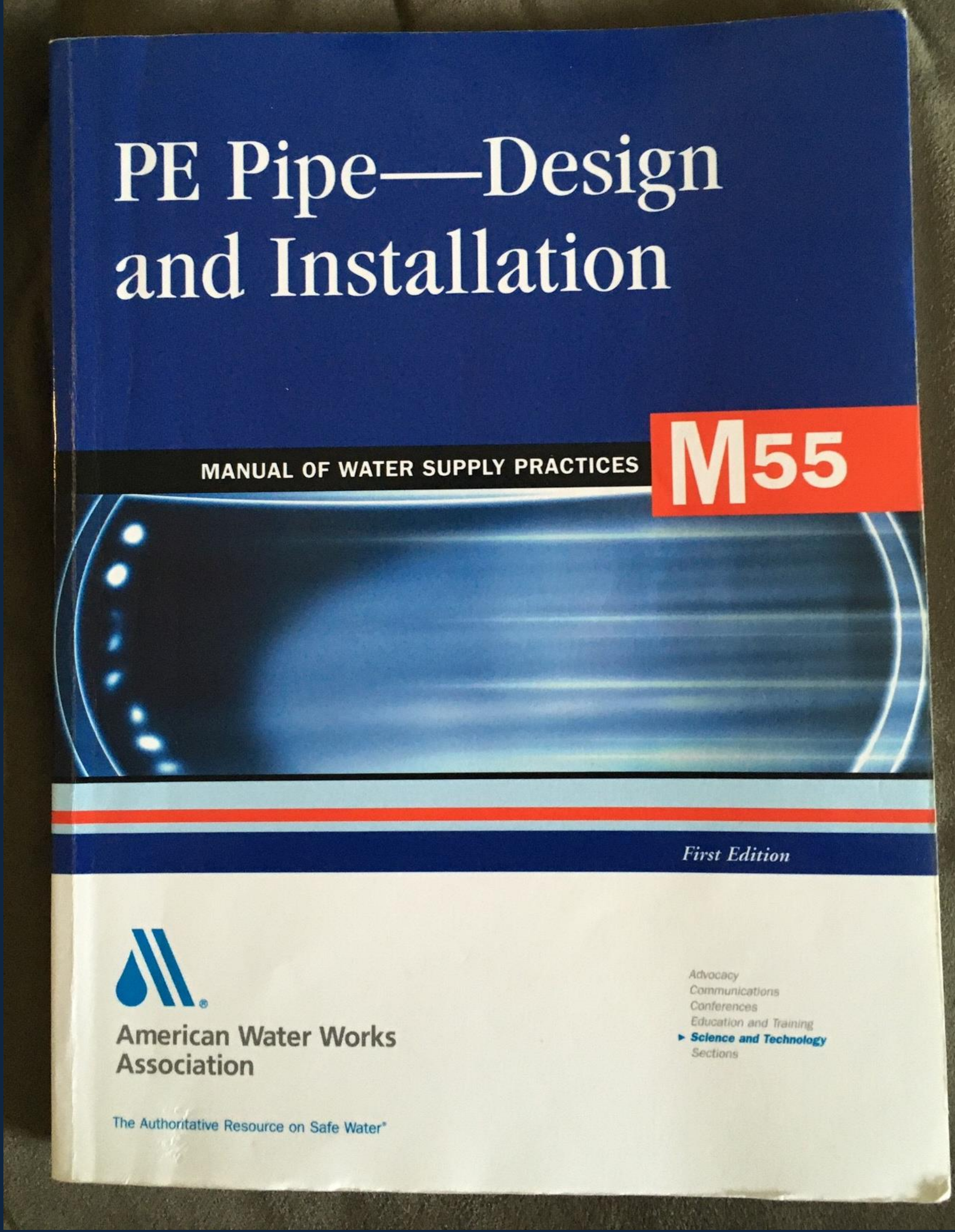
UCT 2020



First Edition

2006

AWWA M55
PE PIPE –
DESIGN AND INSTALLATION
2020 CHANGES Second Edition

- CONFORM TO ASTM D 2774
- UPDATED
- NEW MATERIAL

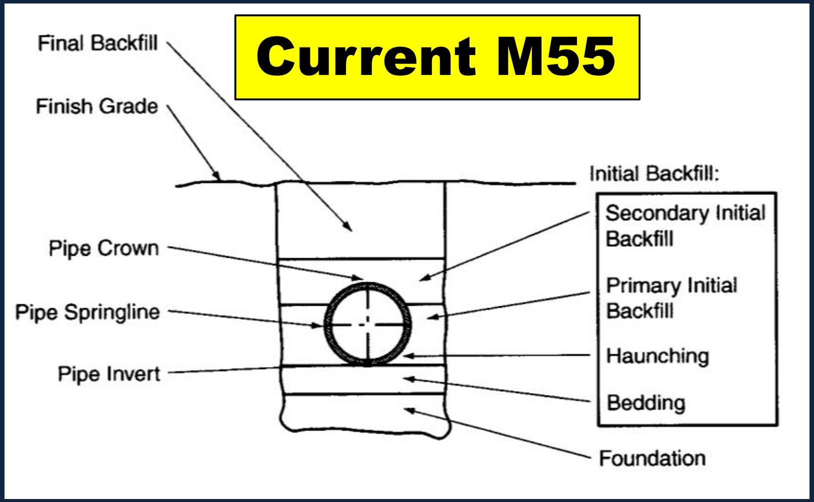
AWWA M55
PE PIPE –
DESIGN AND INSTALLATION
2020 CHANGES

The previous sections on:
"Special Installation Techniques"
(trenchless installation)
and
"Marine Installations"
became new Chapters.

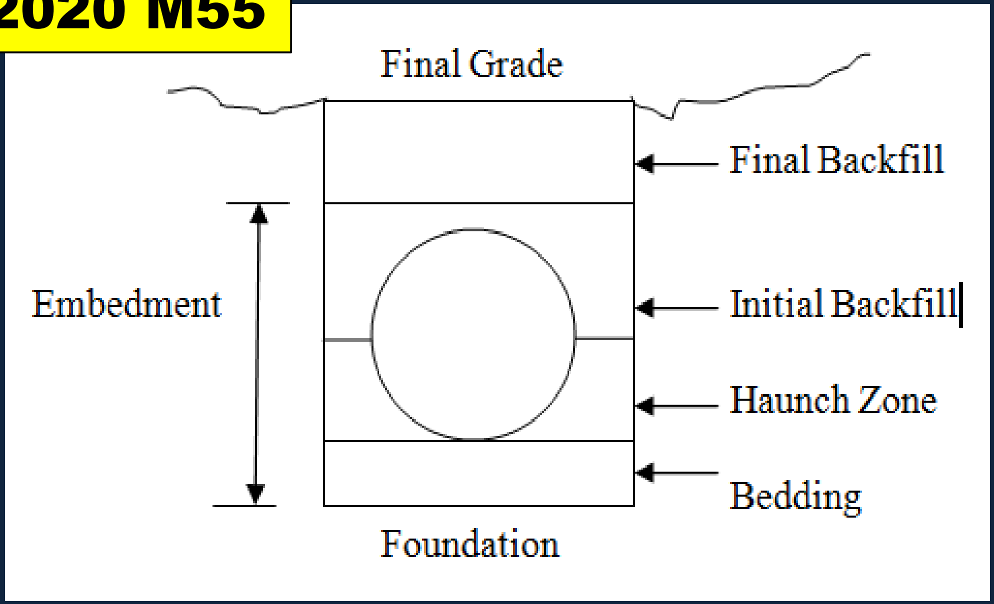
Covers new PE4710 material

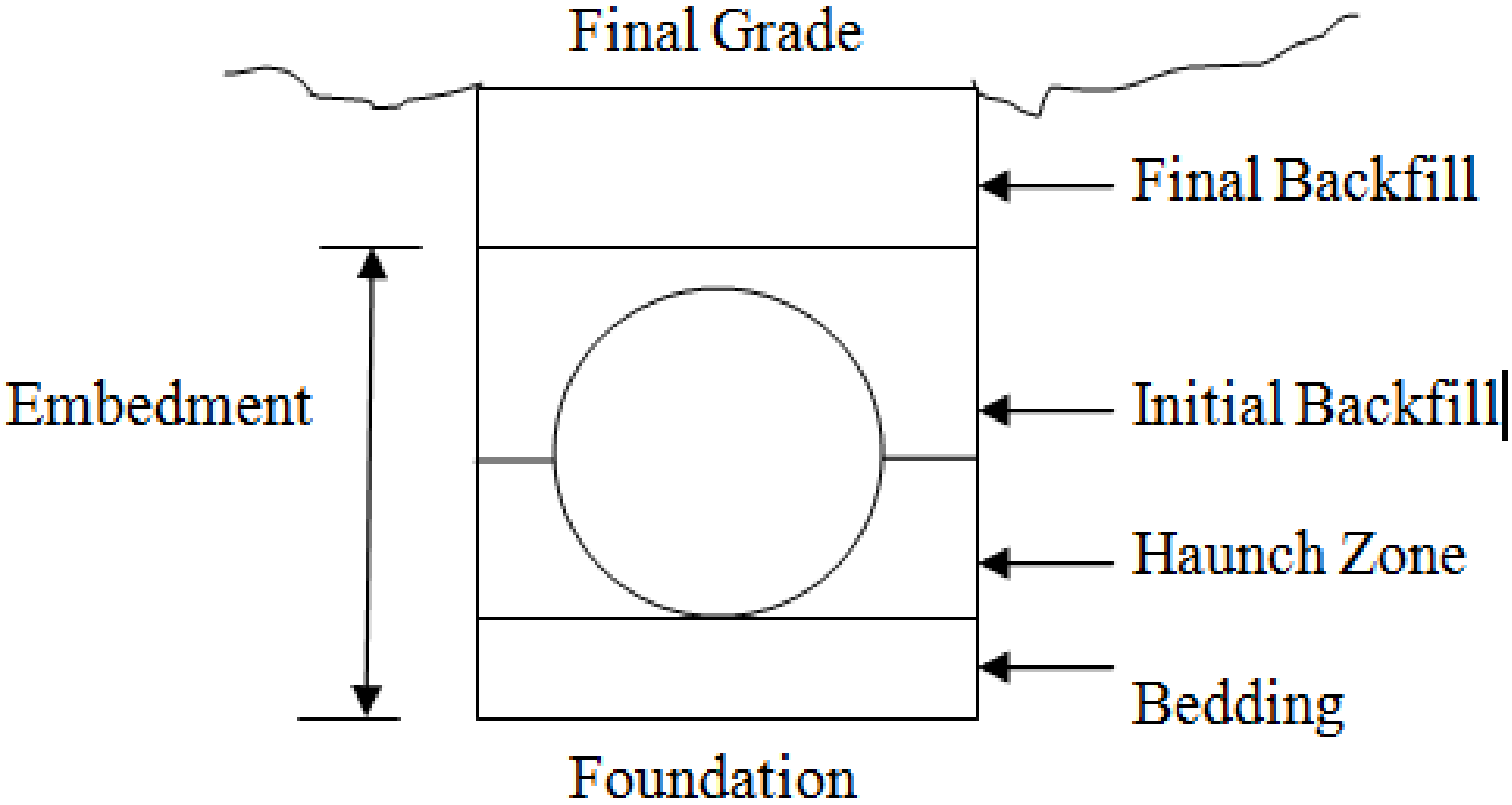
TRENCH TERMS

Current M55



Revised 2020 M55




Final Grade
Final Backfill
Embedment
Initial Backfill
Haunch Zone
Bedding
Foundation

Foundation The foundation is the native soil in the bottom of the excavation. If the foundation is unsuitable, Remediation will be required to provide a stable trench bottom.

Bedding The bedding is the soil placed in the bottom of the trench on top of the foundation.
The bedding serves as a cushion for the pipe

Haunch Zone The haunch zone is from the bottom of the pipe up to the springline. The haunch zone and the initial backfill provide the side support for the pipe that resists deflection.

Initial Backfill The initial backfill extends from the top of the haunch zone to 12 inches above the top of the pipe. The Initial backfill combined with the haunch zone act as lateral support for the pipe.

Embedment The embedment includes the bedding, haunch zone, and initial backfill.

Final Backfill The final backfill extends from the top of the initial backfill to the final grade.

Current table 8-3 M55
(soil groups)

Embedment Backfill Class	Soil Description - Pipe Embedment Material*
Class I	Manufactured angular, granular material with li[illegible]tle or no fines. Angular crushed stone, particle size ¼ in. to 1½ in[illegible]g materials of regional significance such as marl, coral, cr[illegible]ers, slag, etc.
Class II	Coarse-grained soils with litt[illegible]SW, SP† containing less than 12% fines
Class III	Coarse-grained s[illegible]SP containing more than 12% fines
Class IVa	Fine-grained soils [illegible]s with medium to no plasticity—CL, ML, ML-CL with more th[illegible]% coarse-grained particles
Class IVb	Fine-grained soils (LL > 50); soils with medium to high plasticity—CH, MH, CH-MH. Fine-grained soils (LL < 50); soils with medium to no plasticity—CL, ML, ML-CL with less than 25% coarse-grained particles

D 2774
Was updated

New table 8-1 replaces old table 8-3
Current D 2774

CLASS I	Crushed Rock	
CLASS II	Clean, Coarse-Grained Soils	GW GP SW SP
CLASS III	Coarse-Grained Soils w/ Fines	GM GC SM SC
	Sandy/Gravelly Fine Grained Soils	ML CL ML CL
CLASS IV	Fine Grained Soils	ML CL
CLASS V	Fine Grained Soils Organic Soils	MH CH OH OL Pt

PVC sewer pipe embedment shall be Class II soil. The embedment for fiberglass pipe for the discharge pipe shall be SC2 soil. The Concrete pipe storm drain shall be embedded in Category I soil. Install the ductile iron water pipe in Type 4 laying condition. Steel pipe shall be embedded with coarse-grained soils with little or no fines. The PE storm drain embedment shall be Class II soil. Clay pipe shall be embedded with suitable bedding material. Embedment for CMP shall be structural backfill. The PE pressure pipe embedment shall be clean gravel. The low-head concrete pipe shall use granular soil with less than 5% fines.

Use Class II material for embedment
for all pipe types.

ADOPTED:

C12	clay pipe
D2321	gravity thermoplastic
D2774	pressure thermoplastic
AWWA C 605	PVC
D3839	fiberglass
M 45	fiberglass pipe
M23	pressure PVC
M55	pressure PE

IN PROGRESS:

M9	concrete pressure pipe

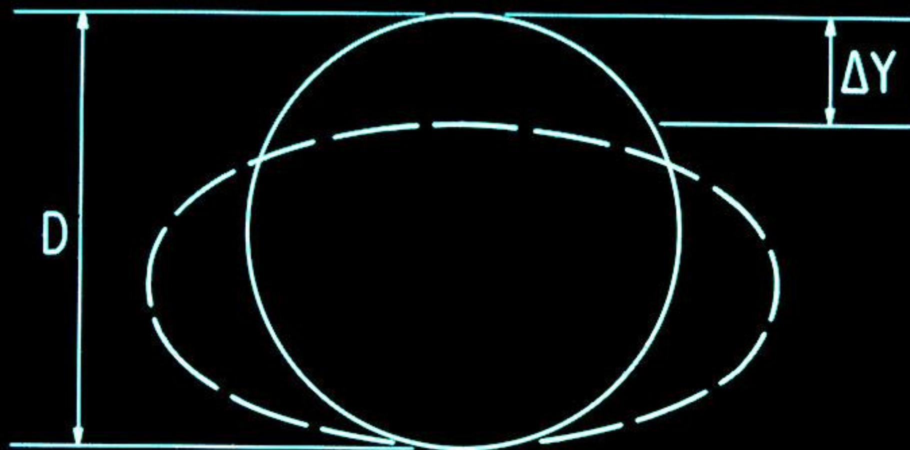
UPDATE

E Prime Table

E Prime Table for native soils

Percent Compaction

Add Vibratory Hammer for maximum density of cohesionless soils



DEFLECTION

$$\frac{\Delta Y}{D} \text{ IN } \%$$

DECREASE IN VERTICAL DIAMETER
DUE TO SOIL LOAD ON PIPE

D = PIPE DIAMETER WHEN SOIL PLACED
TO TOP OF PIPE (OR 0.7 O.D.)

$$\text{Deflection} = \frac{\text{Load}}{\text{pipe stiffness} + \text{soil stiffness}}$$

$$\text{strain} = \frac{\text{stress}}{\text{modulus}}$$

UPDATE

Soil Type-Pipe Bedding Material (Unified Classification System)*	E' for Degree of Bedding Compaction, $lb/in.^2$			
	Dumped	Slight, <85% Proctor, <40% relative density	Moderate, 85%-95% Proctor, 40%-70% relative density	High, >95% Proctor, >70% relative density
Fine-grained soils (LL > 50)† Soils with medium to high plasticity CH, MH, CH-MH	No data available: consult a soil engineer, or use $E' = 0$.			
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with less than 25% coarse grained particles	50	200	400	1,500
Fine-grained soils (LL < 50) Soils with medium to no plasticity CL, ML, ML-CL, with more than 25% coarse grained particles Coarse-grained soils with fines GM, GC, SM, SC‡ contains more than 12% fines	150	400	1,000	2,500
Coarse-grained soils with little or no fines GW, GP, SW, SP‡ contains less than 12% fines	200	700	2,000	3,000
Crushed rock	1,000	1,000	3,000	3,000

Current M55 E Prime table 5-7

UPDATED

SOIL STIFFNESS - E′

	NO COMPACTION	MODERATE COMPACTION	HIGH COMPACTION
CLASS I Crushed rock	1000	6000	
CLASS II GW GP SW SP	500	2000	4000
CLASS III GC GM SC SM CL CL ML ML	200	1000	2500
CLASS IV CL ML	100	400	1500
CLASS V CH MH OH OL	Do Not Use		

UPDATE

SOIL STIFFNESS - E′

	NO COMPACTION	MODERATE COMPACTION	HIGH COMPACTION
CLASS I Crushed rock	1000	6000	
CLASS II GW GP SW SP	[illegible]	[illegible]	[illegible]
CLASS III GC GM SC SM CL CL ML ML	[illegible]	[illegible]	[illegible]
CLASS IV CL ML	100	400	1500
CLASS V CH MH OH OL	Do Not Use		

*Use new soil classes
*Reverse order
*Combine dumped and slight compaction
*Revised values – most higher

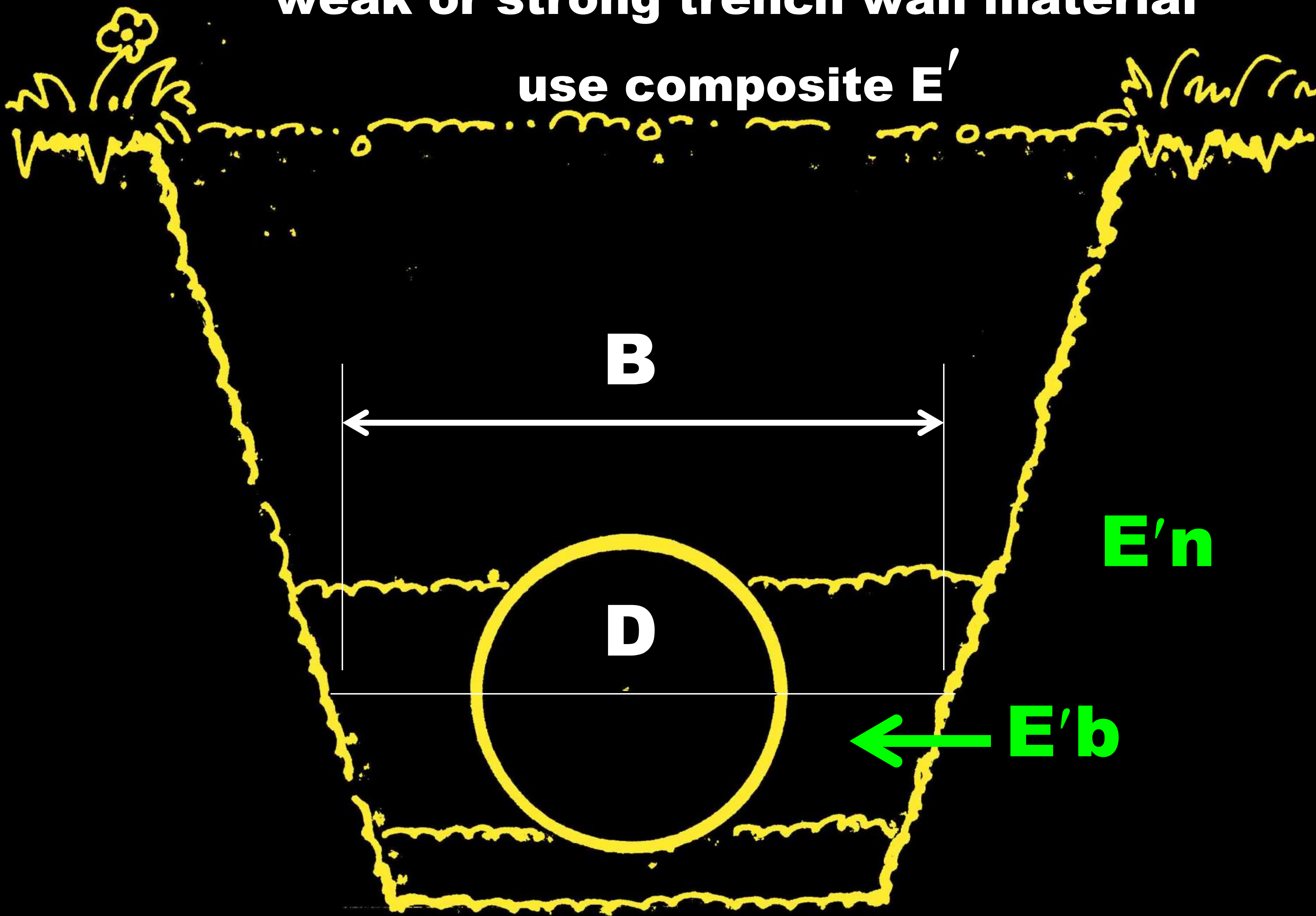
SOIL STIFFNESS - E′

	NO COMPACTION	MODERATE COMPACTION	HIGH COMPACTION
CLASS I Crushed rock	1000	6000	
CLASS II GW GP SW SP	500	2000	4000
CLASS III GC GM SC SM sCL gCL sML gML	200	1000	[illegible]
CLASS IV CL ML	100	4[illegible]	1500
CLASS V CH MH OH OL	Do Not Use		

Means deeper burial

weak or strong trench wall material

use composite E′



Composite E Prime

if $E'b$ = 1000

Composite E' = S (1000)

S = soil support combining factor

TABLE 9-1
S values

E' native/ E' embed	B/D=2	B/D=5	E'
0.1	0.30	1.0	300
1.0	1.0	1.0	1000
5.0	1.6	1.0	1600

Where B = trench width D = pipe diameter

UPDATE

M55 Table 5-9 Native E Prime

Native In Situ Soils				
Granular		Cohesive		
Std. Penetration ASTM D1586, blows/ft	Description	Unconfined Compressive Strength (TSF)	Description	*E'_N (psi)*
>0-1	very, very loose	>0-0.125	very, very soft	50
1-2	very loose	0.125-0.25	very soft	200
2-4	very loose	0.25-0.50	soft	700
4-8	loose	0.50-1.00	medium	1,500
8-15	slightly compact	1.00-2.00	stiff	3,000
15-30	compact	2.00-4.00	very stiff	5,000
30-50	dense	4.00-6.00	hard	10,000
>50	very dense	>6.00	very hard	20,000
Rock	—	—	—	≥50,000

Soil description and classification - USCS	N_{60} Value from SPT test (number of blows/foot)					
	0 – 4	5	10	20	30	≥50
Clays and silts with <30% Sand/gravel **CL ML**	zero	500	750	1250	1500	2500
Sandy silts, clays With ≥ 30% sand **CL ML** Silty or Clayey sand **SM SC**		700	1000	1500	2000	3000
Normally consolidated sands **SP, SP-SM, SP-SC**		1000	1500	2500	3000	5000
Over-consolidated sands **SP, SP-SM, SP-SC**		2000	3000	4000	5000	8000
Gravels, soils with Gravel		Typically higher than sands but SPT test very unreliable, use another method				

UPDATE

New Table 5-9 Native E Prime Values

Soil description and classification - USCS	N_{60} Value from SPT test (number of blows/foot)					
	0 – 4	5	10	20	30	≥50
Clays and silts with <30% Sand/gravel **CL ML**	zero	500	750	1250	1500	2500
Sandy silts, clays With ≥ 30% sand **CL ML** Silty or Clayey sand **SM SC**	zero	700	1000	1500	2000	3000
Normally consolidated sands **SP, SP-SM, SP-SC**	zero	1000	1500	2500	3000	5000
Over-consolidated sands **SP, SP-SM, SP-SC**	zero	2000	3000	4000	5000	8000
Gravels, soils with Gravel	zero	Typically higher than sands but SPT test very unreliable, use another method				

UPDATE

PERCENT COMPACTION

UPDATE

Different names used in

SOIL COMPACTION

- **Percent Compaction**
- **Percent Proctor**
- **Percent Standard Proctor**
- **Percent Modified Proctor**
- **Relative Compaction**
- **Relative Density**
- **Relative Proctor Density**
- **Density**

UPDATE

ASTM D 653 recommendation

The backfill shall be compacted to 95% (D 698) or more.

UPDATE

ASTM D 653 recommendation

The backfill shall be compacted to 95% (D 698) or more.

percent of maximum density

test for maximum density

ASTM D 653 recommendation

The backfill shall be compacted to 95% (D 698) or more.

percent of maximum density

test for maximum density

Cohesive soils (clays and silts)

- ASTM D 698
- ASTM D 1557
- AASHTO T-99

Cohesionless soils (sand and gravel)

- D 7382
- D 4253

UPDATE

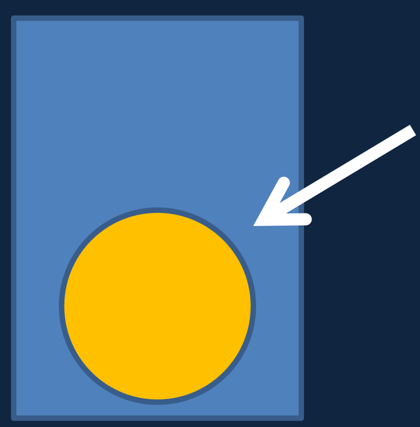
ASTM D 653 recommendation

The backfill shall be compacted to 95% (D 698) or more.

Compact the backfill to 95% (D 1557) or more.

The minimum percent compaction shall be:

embedment	95% (D 7382)
backfill	85% (D 698)
backfill under roads	95% (D1557)



=/> 95% (T-99)

ASTM D 653 recommendation

The backfill shall be compacted to 95% (D 698) or more.

percent of maximum density

test for maximum density

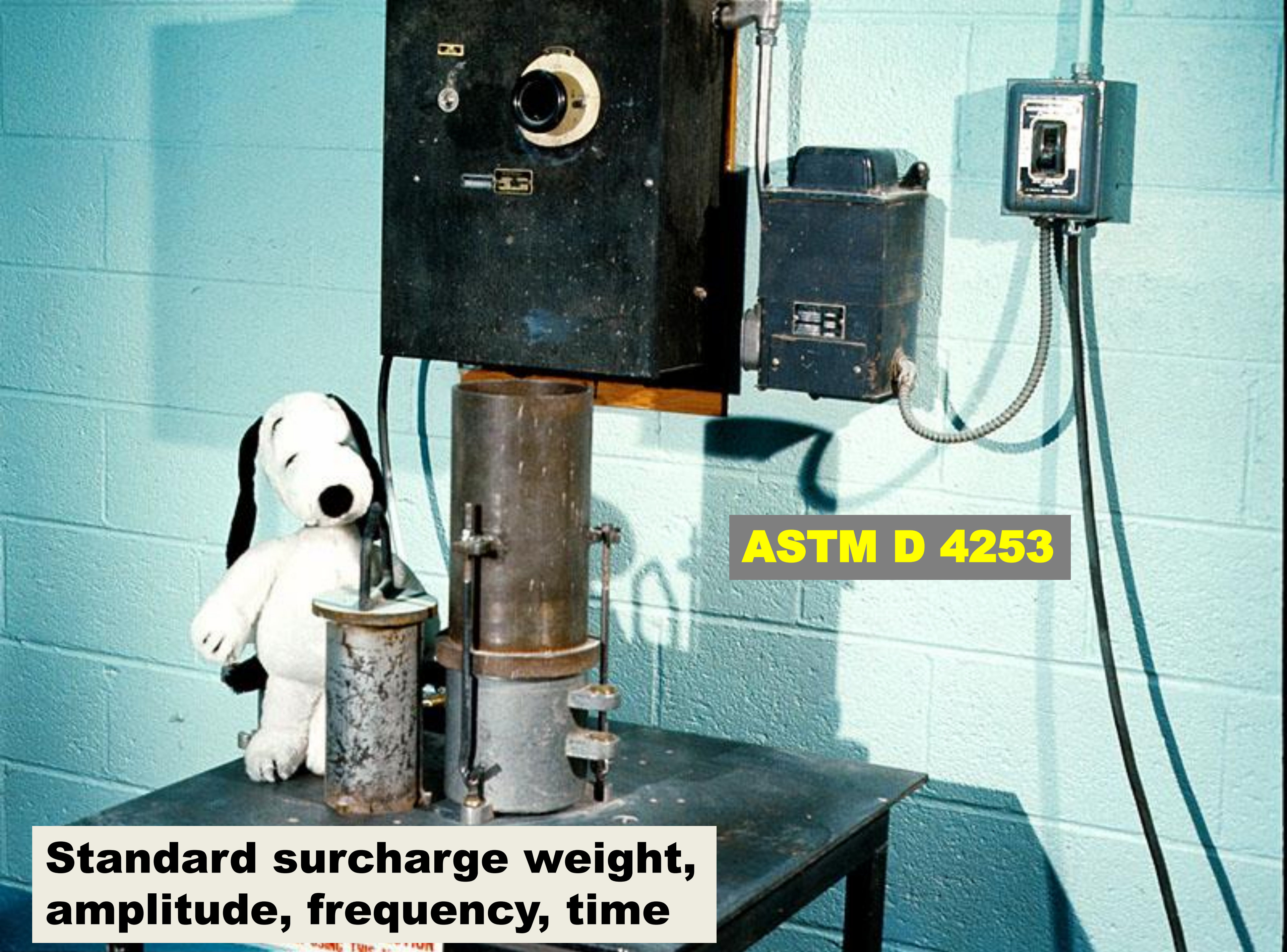
Cohesionless soils (sand and gravel)

D 7382

D 4253

UPDATE

ADD VIBRATING TABLE FOR DETERMINING MAXIMUM DENSITY OF COHESIONLESS SOILS



ASTM D 4253

Standard surcharge weight, amplitude, frequency, time

D 7382

Max Density Using Vibe hammer

UPDATE

basic installation

engineered installation

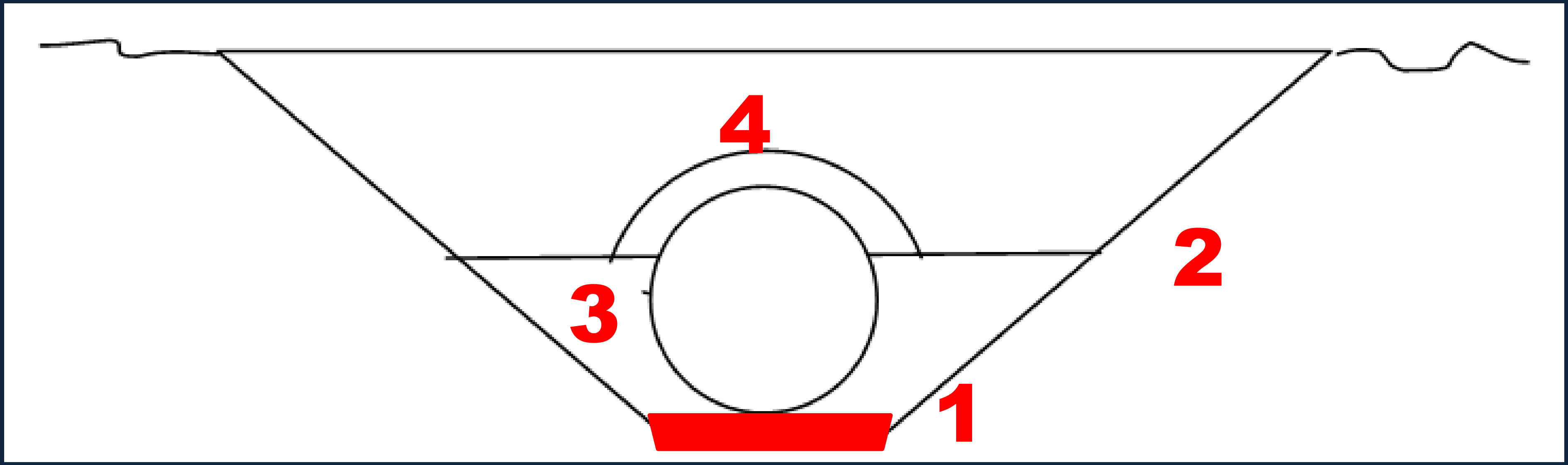
BASIC INSTALLATION

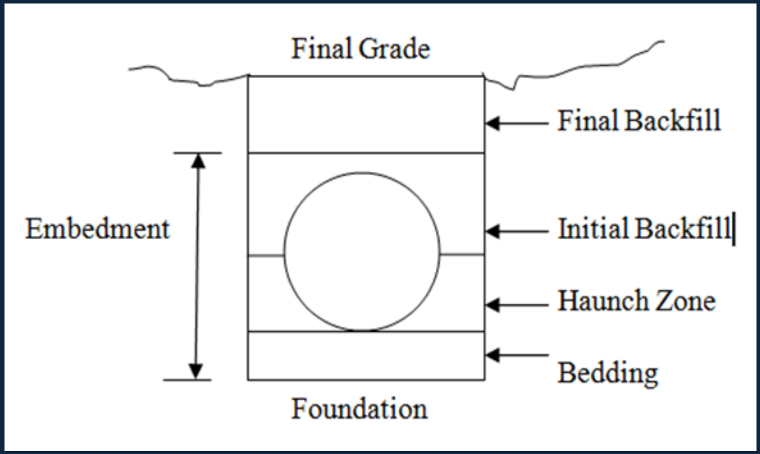
- Pipe diameter of 24 inches or less
- DR equal to or less than 21
- Depth of cover 10 ft or less
- No live load nor surcharge load for cover 6 ft or less
- Ground water below pipe
- Embedment E′ at least 200 psi
- Foundation not expansive clay, collapsing soil, or landfill
- Foundation, embedment max particle size limit
- The native trench walls are stable and have a minimum unconfined compressive strength of 5 psi , a N value of at least 5 (Standard Penetration Test), or an E′ of at least 400 psi.
- The backfill over the pipe does not need compaction

An engineered installation should be used when these conditions are not met.

Engineered Installation

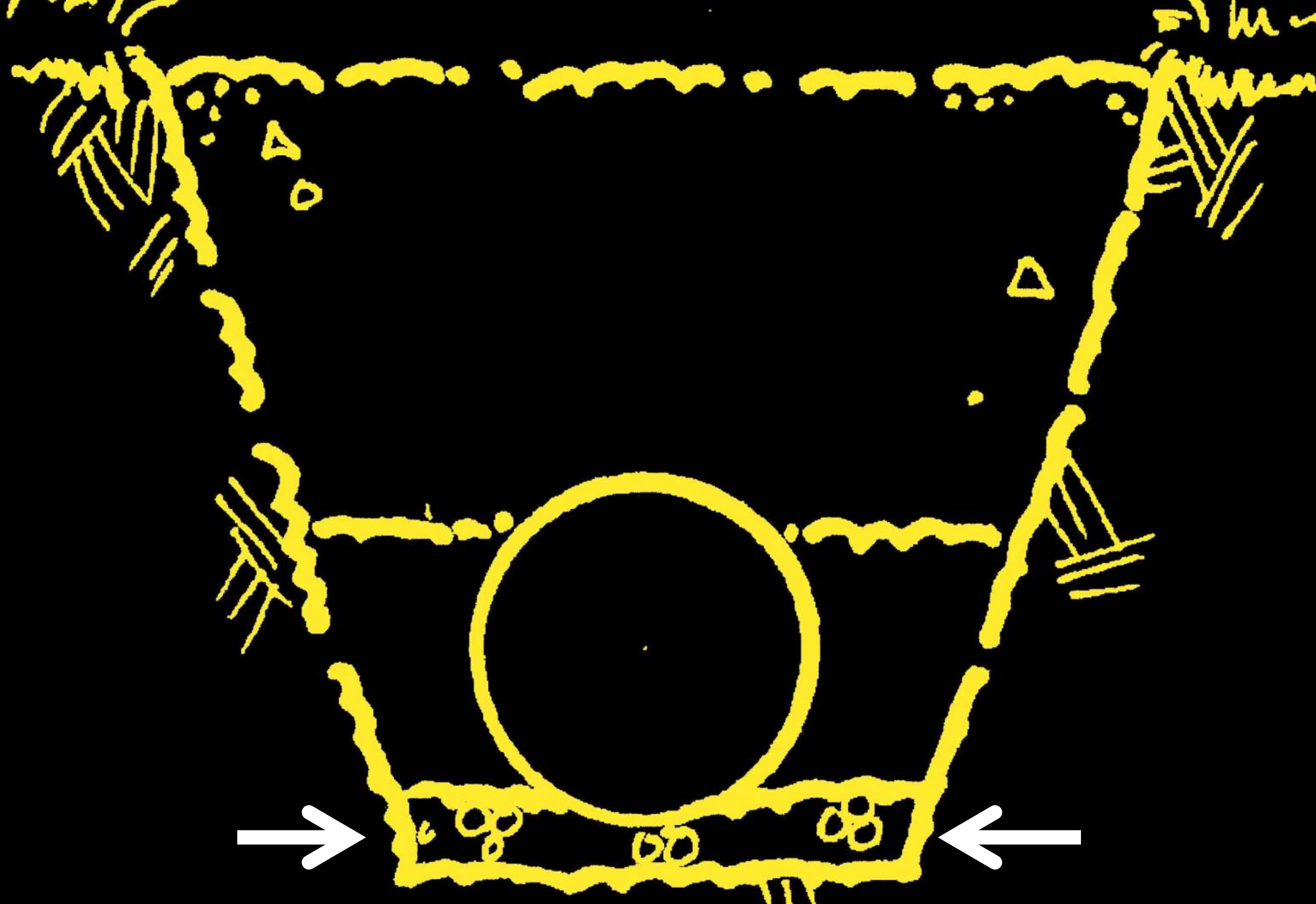
Check deflection and buckling





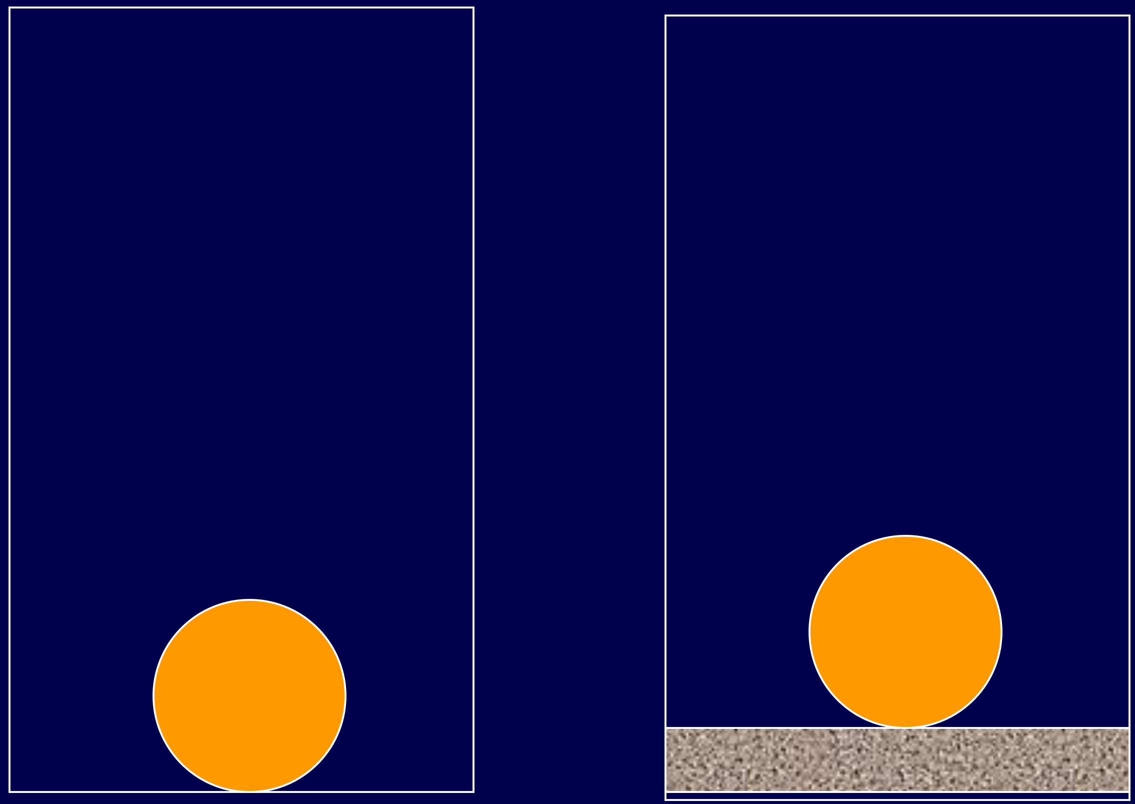
1 uncompacted bedding
clean gravel, crushed rock
2 0.7 OD embedment
3 E prime
4 uncompacted padding

CHAPTER 10



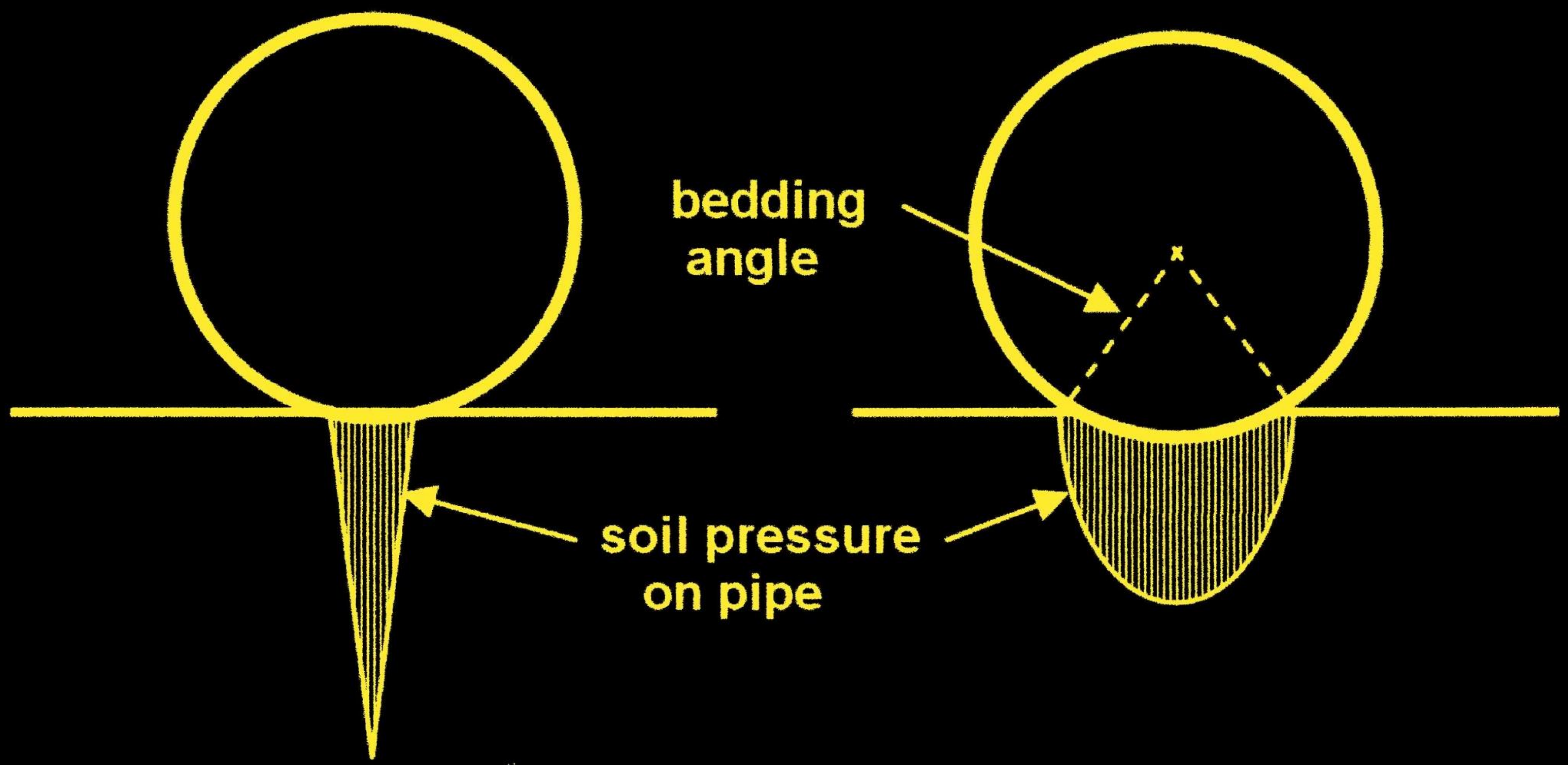
BEDDING

BEDDING

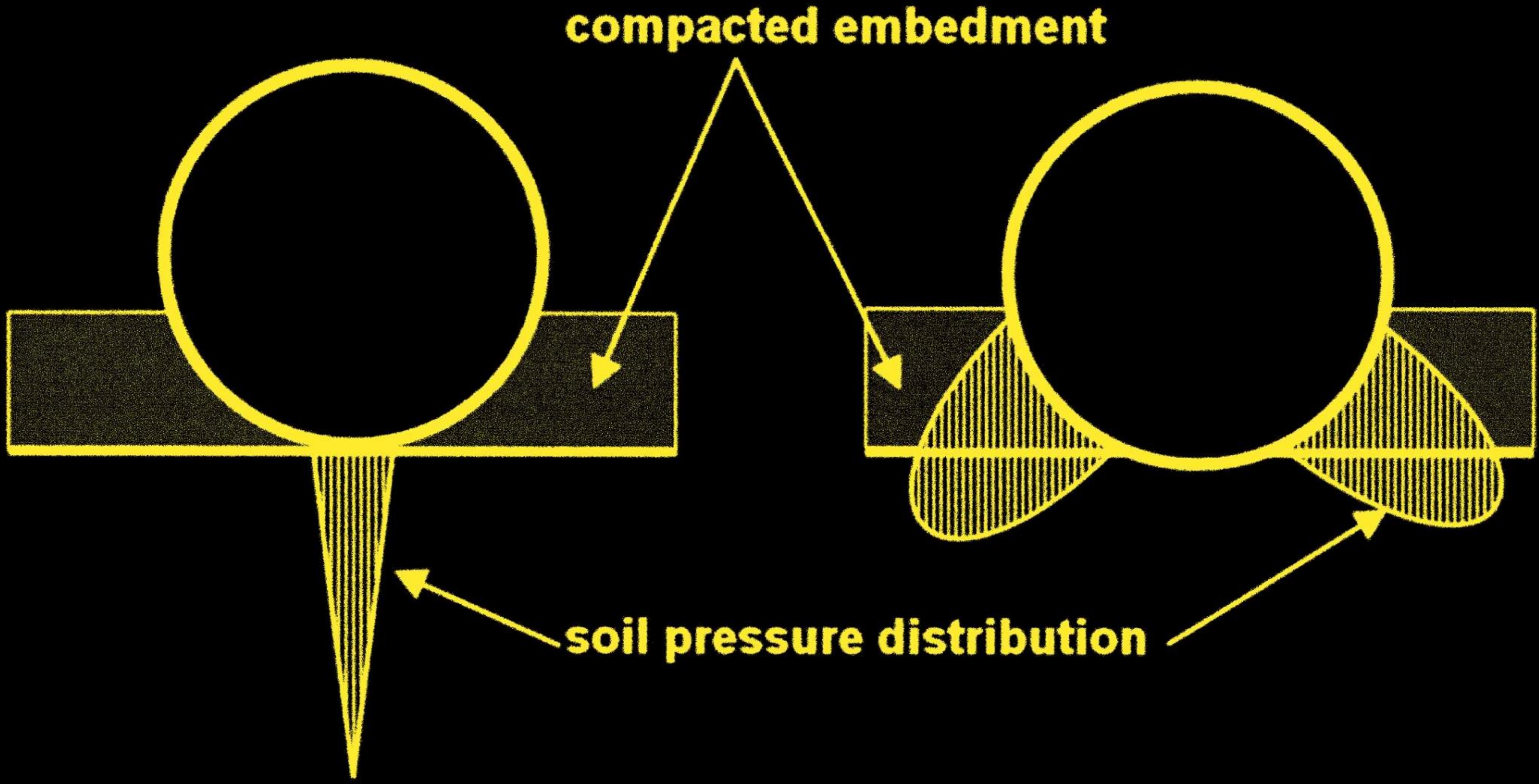


Pipe used to be laid on trench bottom but most current standards/manuals recommend bedding

uncompacted bedding creates small bedding angle

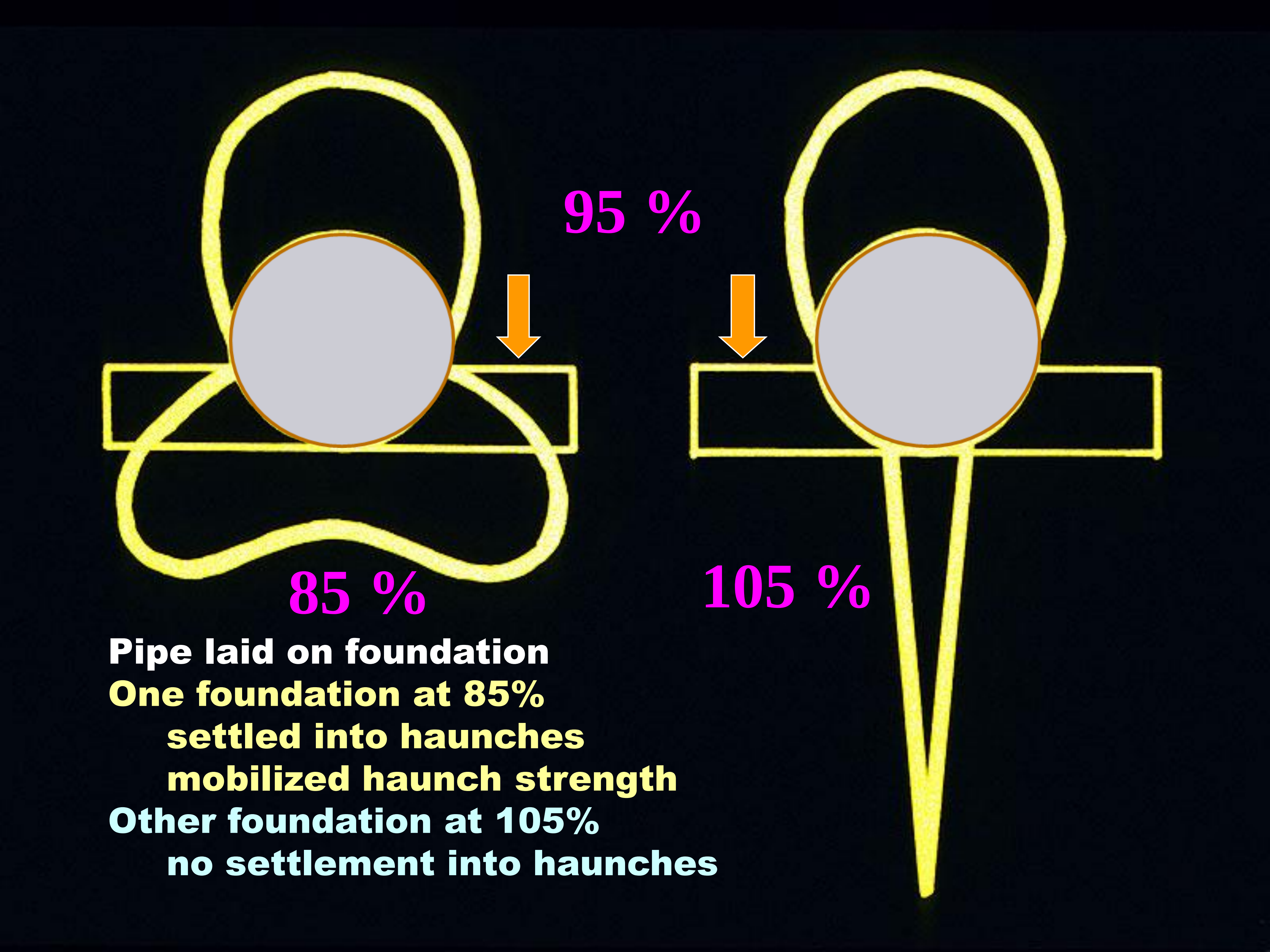


uncompacted bedding helps mobilize embedment support



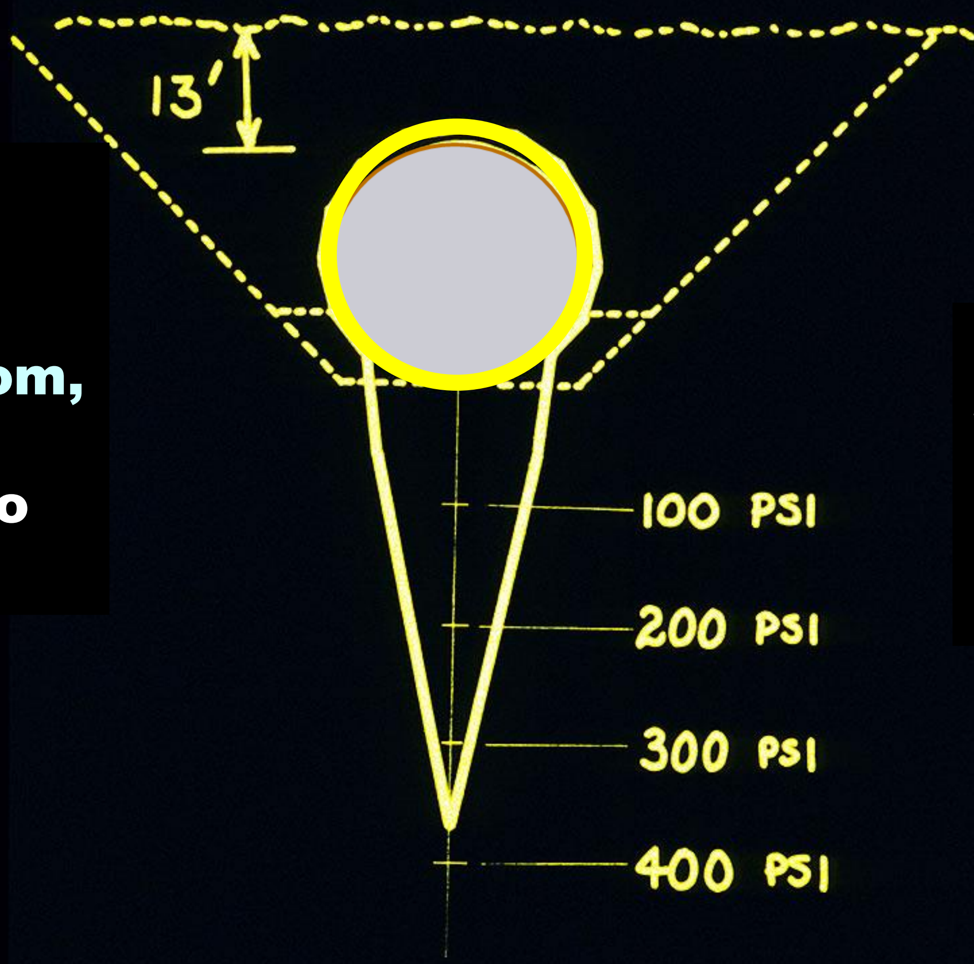
USBR
Soil box tests

- Rigid steel box
- Load applied
  with test machine
- Measured pressures
  on concrete pipe

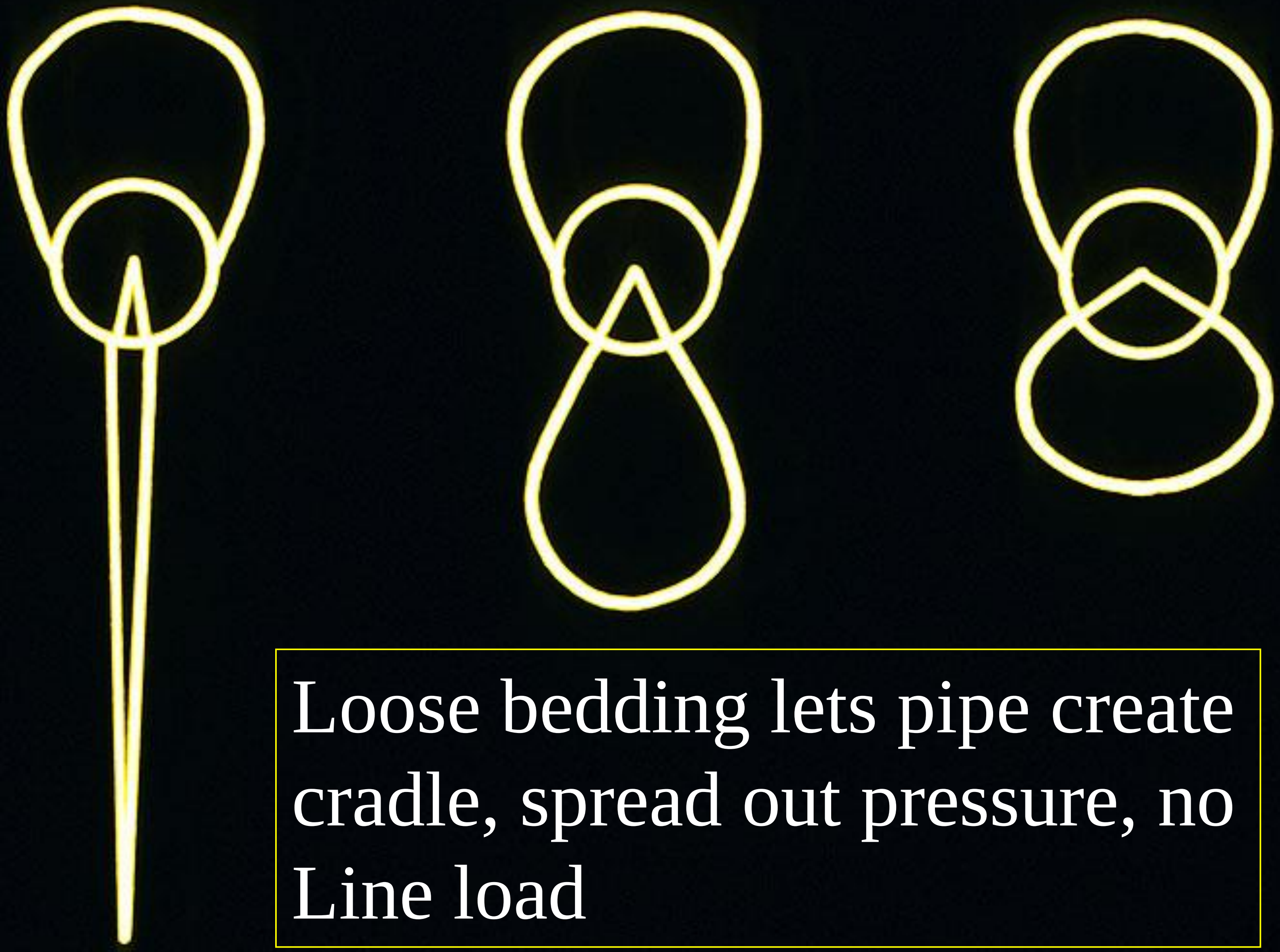

95 %
85 %
105 %
Pipe laid on foundation
One foundation at 85%
settled into haunches
mobilized haunch strength
Other foundation at 105%
no settlement into haunches

Similar result on CAP 25 ft OD Prestressed Concrete Pipe

Each pipe Weighed 225 tons, Laid on bottom, Compressed Foundation to High density

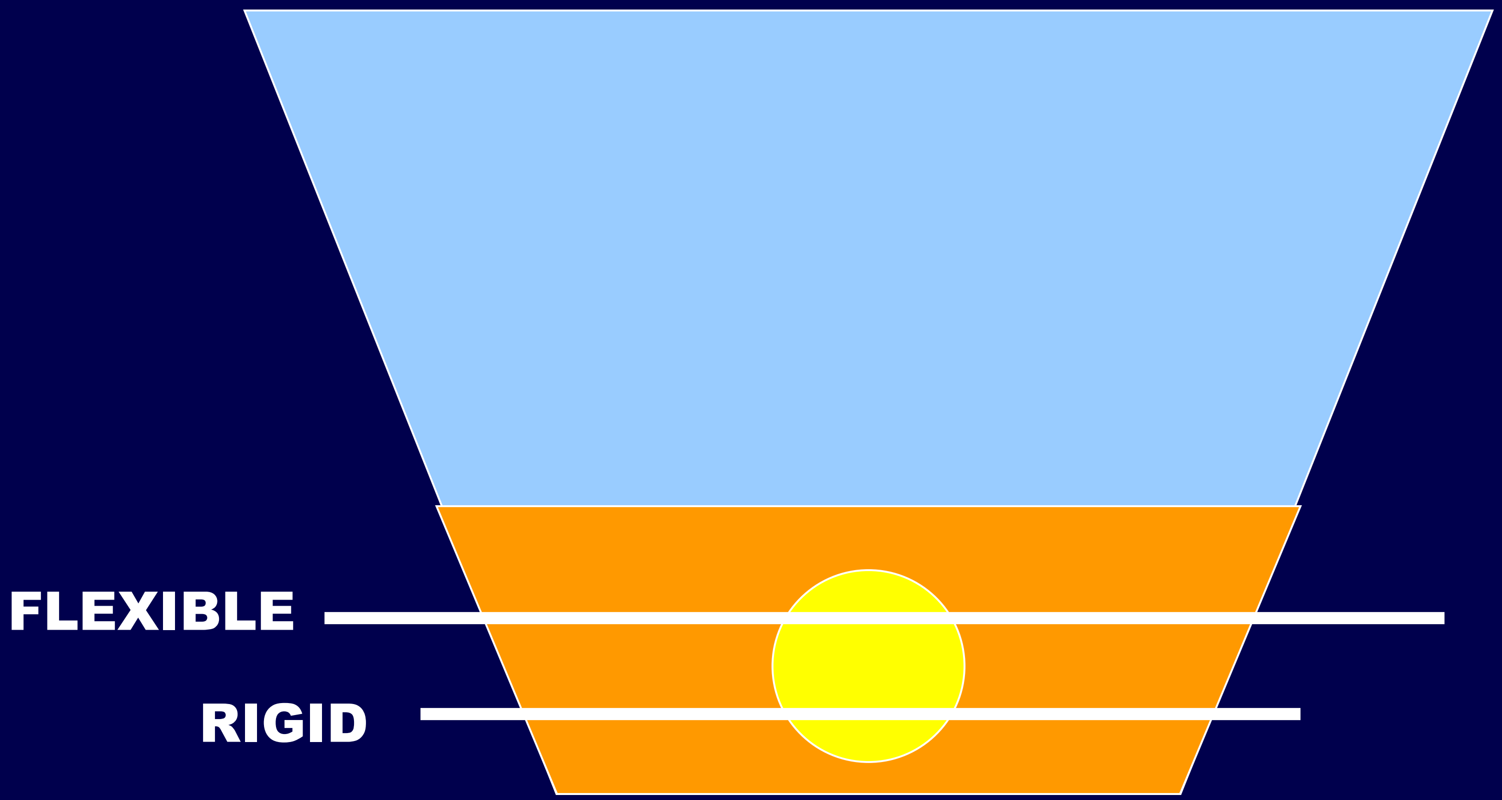


High density Soil in Haunches, Never mobilized



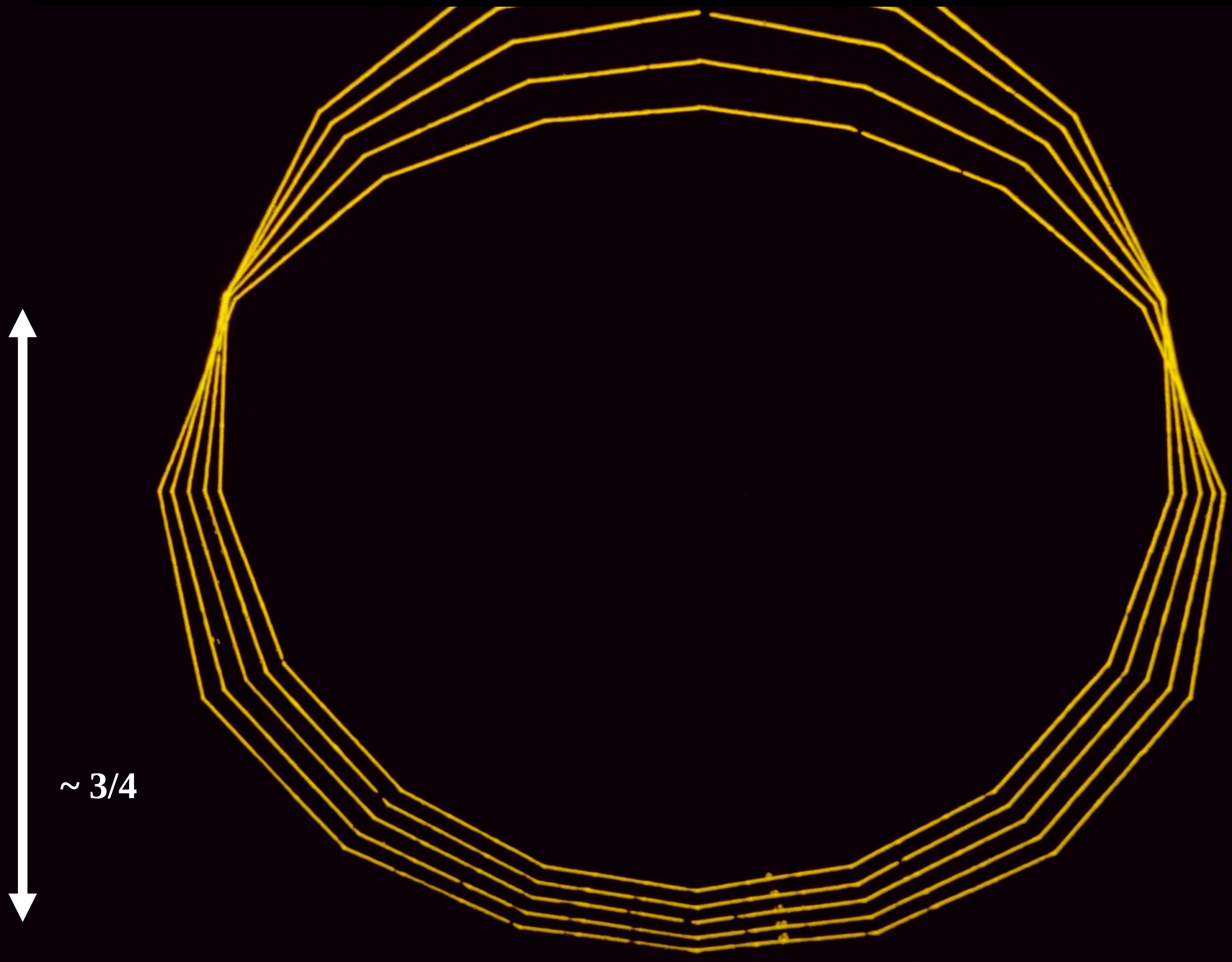
Loose bedding lets pipe create cradle, spread out pressure, no Line load

Most standards require 6” to 12” COMPACTED embedment over pipe

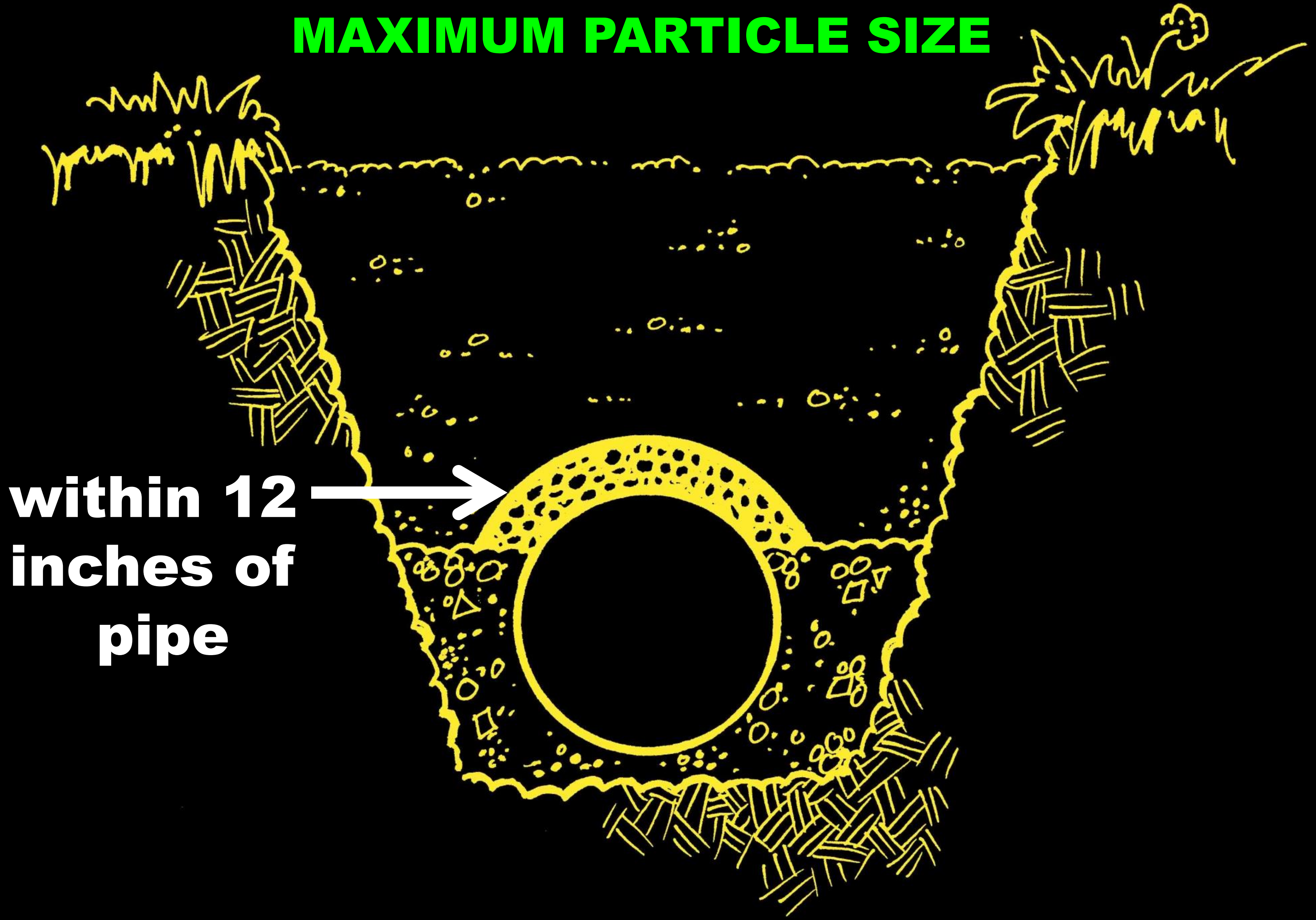


IF IMPORTED, PROCESSED EMBEDMENT MATERIAL, UNNECESSARY COSTS

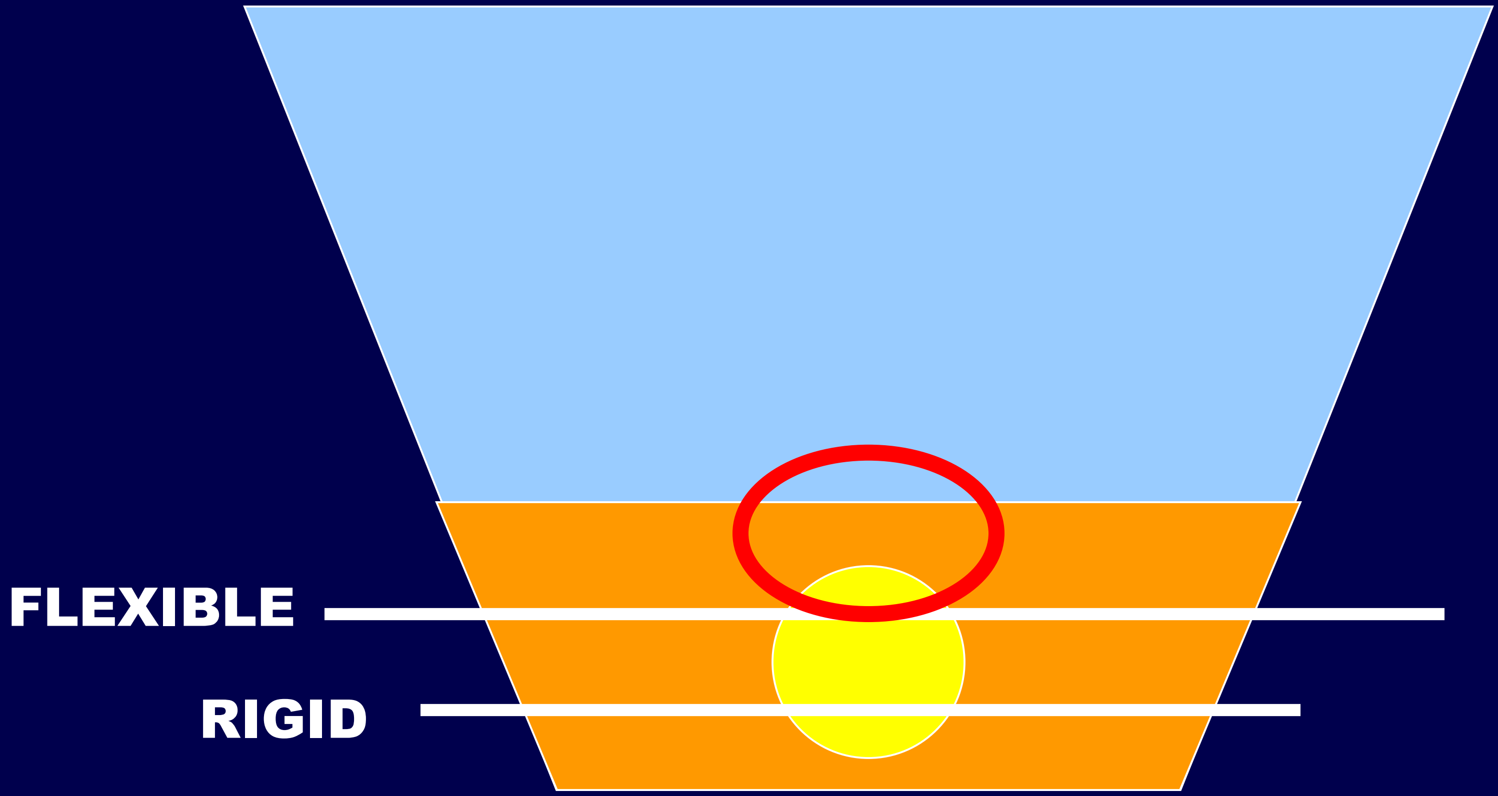
Side support not necessary above 75% OD



PADDING WITH MAXIMUM PARTICLE SIZE

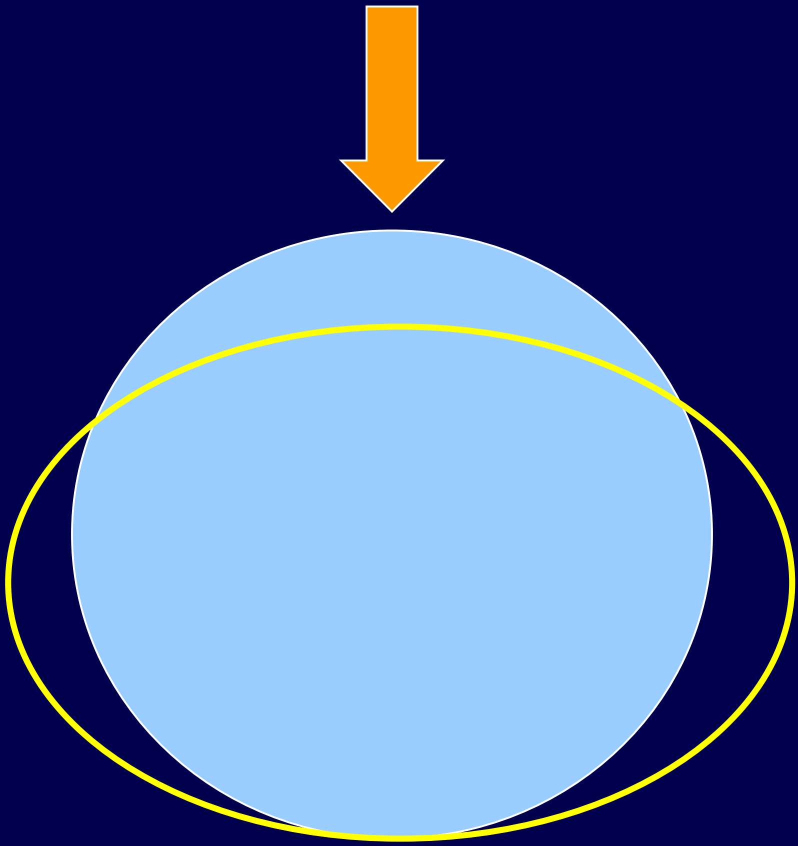


Most standards require 6" to 12" COMPACTED embedment over pipe

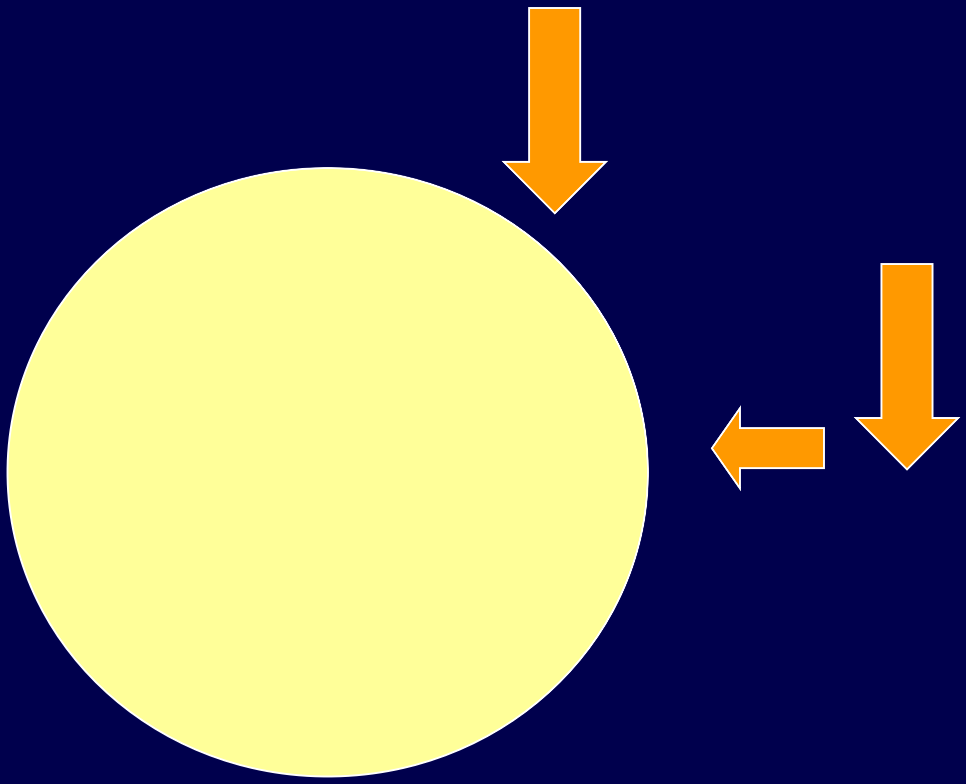


Compaction over pipe

Hard to compact soil to high density over top of pipe



Lateral pressure on pipe=half of vertical
Except when compactor is over pipe
Easy to damage pipe



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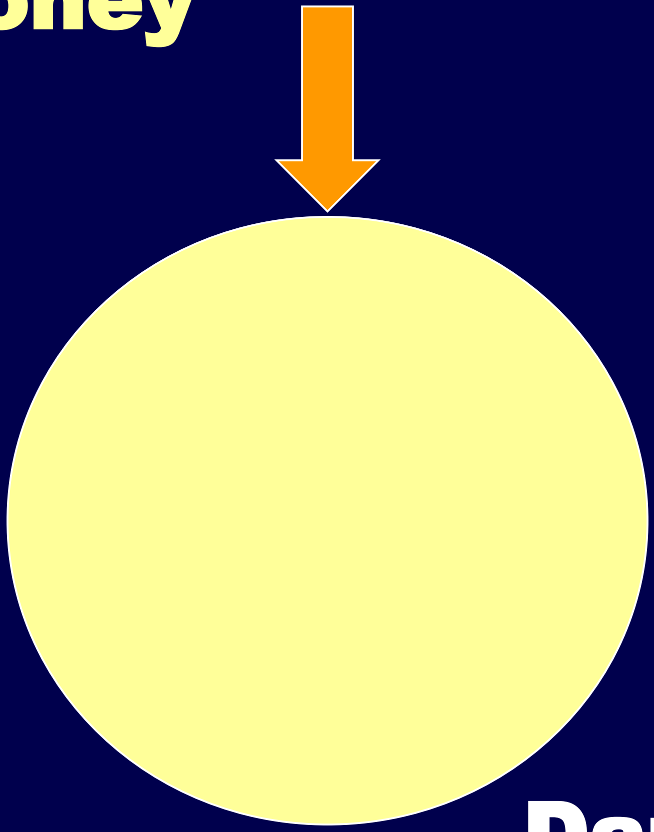
Not Necessary

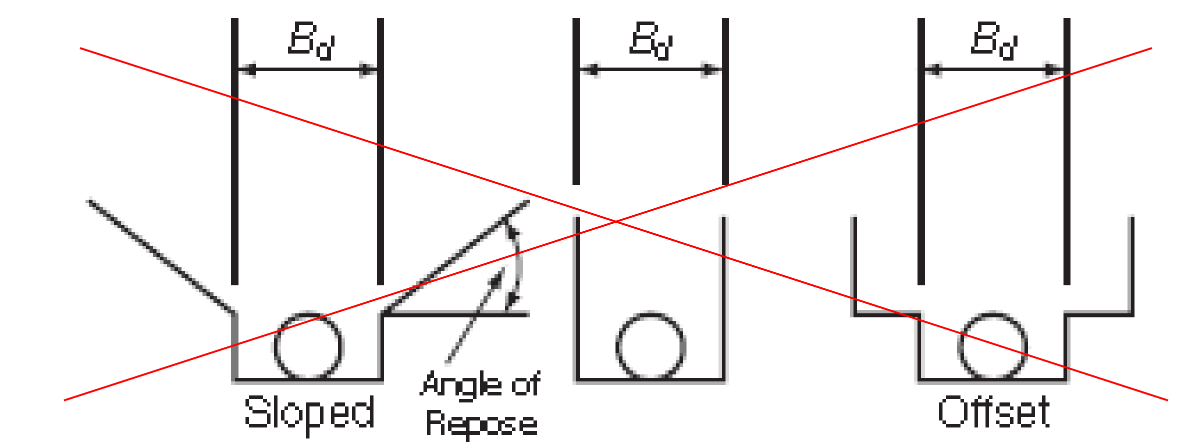
Waste Money



Low Density

Damage Pipe

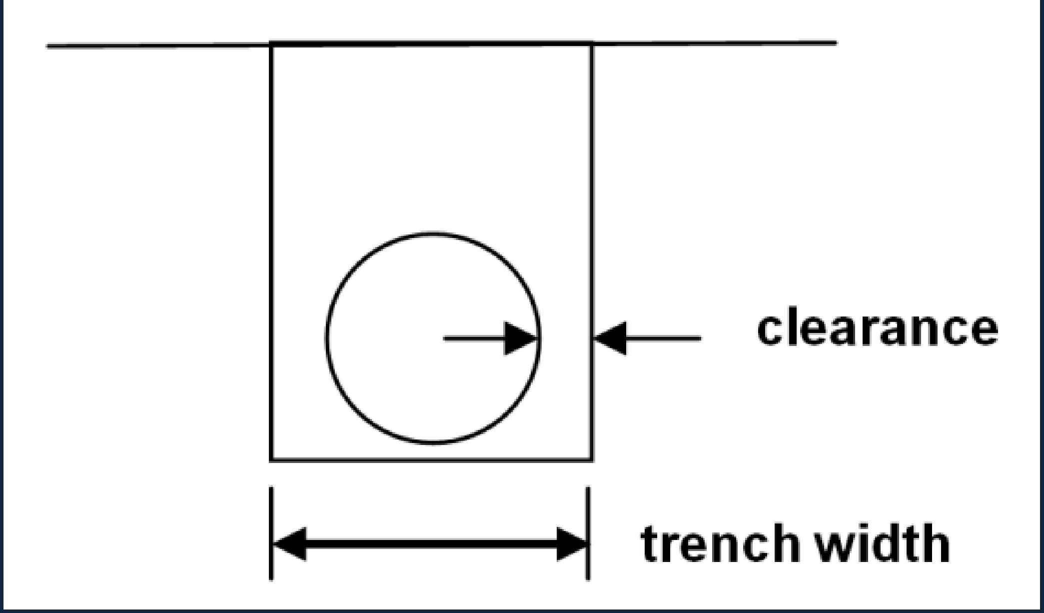
REVISE TRENCH WIDTH



new Fig 8-2

Trench width depends on contractor

For flexible pipe, clearance more important than trench width



REVISE TRENCH WIDTH

The excavated trench will have a width based on the excavation equipment used by the contractor, but this width must allow for clearance between the pipe and trench wall for proper compaction and inspection..

REVISE TRENCH WIDTH

REVISE TRENCH WIDTH

wide trench

narrow trench

REVISE TRENCH WIDTH

Engineered Installation

In some cases, the trench width may need to be increased to obtain the required side support at the springline of the pipe. See Chapter 5 discussion on "Composite E prime".

The required width at springline should be clearly stated in the project documents.

NEW

Flowable Fill Section

SOIL + CEMENT + WATER = FLOWABLE FILL

A mixture of soil, water, and cementitious matter that hardens into a material that has a higher strength than compacted soil. Typically, it has the consistency of thick liquid.

FLOWABLE FILL

- ASTM construction
- control standards
- 50-100 psi strength
- E prime values
- Can use native soil

FLOWABLE FILL

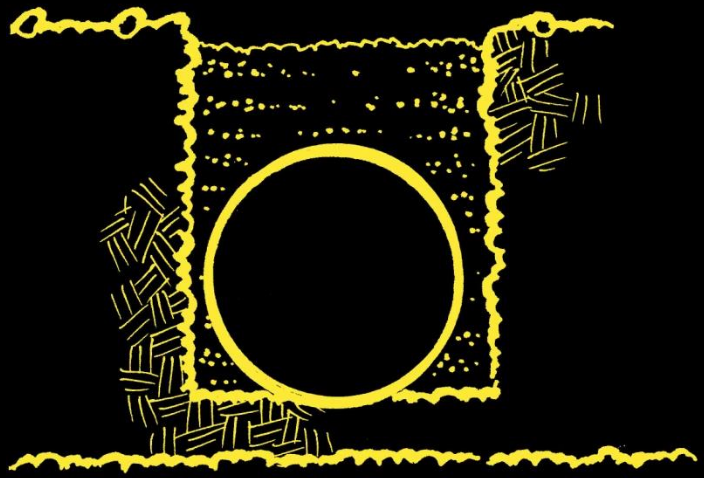
ASTM construction control standards

- compressive strength
- flowability
- set time

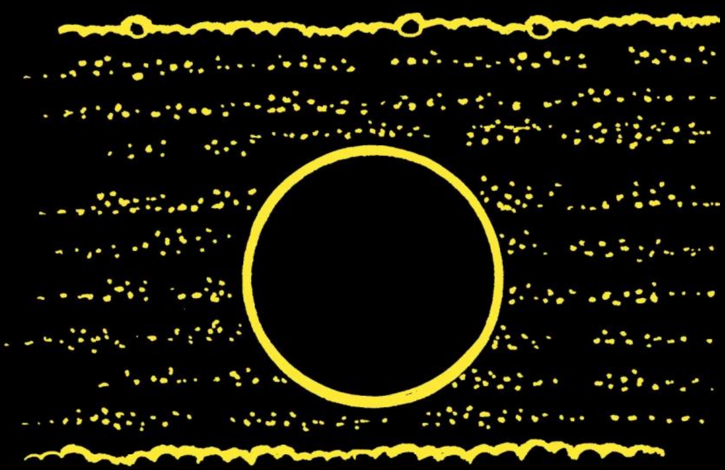
NATIVE FLOWABLE FILL
FAT CLAY (CH) AND CEMENT

[redacted]

NEW



trench condition



embankment condition

NEW

Embankment Condition

A buried pipe may be constructed as part of a new embankment.

For the typical sizes of PE pressure pipe, the most common construction technique is to build the embankment and then excavate a trench for the pipe.

The previous discussion on trench installation would then apply to the embankment condition.

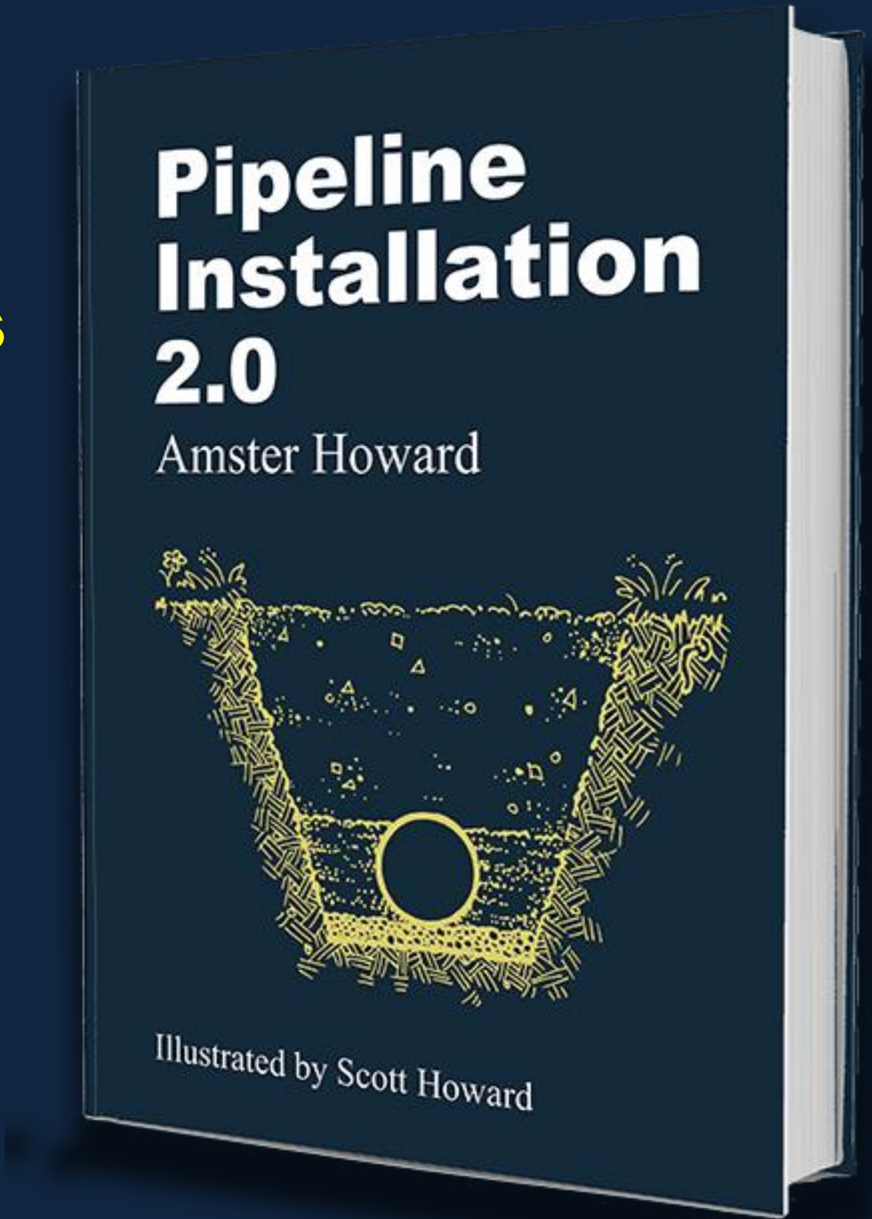
For a composite E′ value, the trench wall stiffness, E'_N, would be the stiffness of the compacted embankment from Table 5-8.

CONFORM TO D 2774

MAXIMUM PARTICLE SIZE

Current M 55	
1/2 inch	2-4 inch pipe
3/4-1 inch	6-8 inch pipe
1-1/2 inch	all other sizes
D 2774 and Revised M 55	
1/2 inch	up to 4 inch pipe
3/4 inch	6-8 inch pipe
1 inch	10-16 inch pipe
1-1/2 inch	larger pipe

Many changes based on this book



SUMMARY

UPDATED TRENCH SECTION

NEW TEST PROCEDURE FOR
COHESIONLESS SOILS

ESTABLISHED:
* Basic Installation
* Engineered Installation

UNCOMPACTED BEDDING
CLEAN GRAVEL, ROCK
0.7 OD EMBEDMENT
UNCOMPACTED BACKFILL OVER PIPE

NEW FLOWABLE SECTION

FINIŠ