Geotechnical Considerations

Compaction, Seepage, Pipe Joints, etc.

by

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Maryland Dam Safety

MDE

Wetter is Better!

- Benefits of Higher Degree of Compaction
  - Higher shear strength
  - Lower permeability
  - Lower compressibility
- Negatives of Higher Degree of Compaction
  - Lower flexibility
  - Hydraulic fracture
  - Higher swell pressures

Embankment Fill Compaction

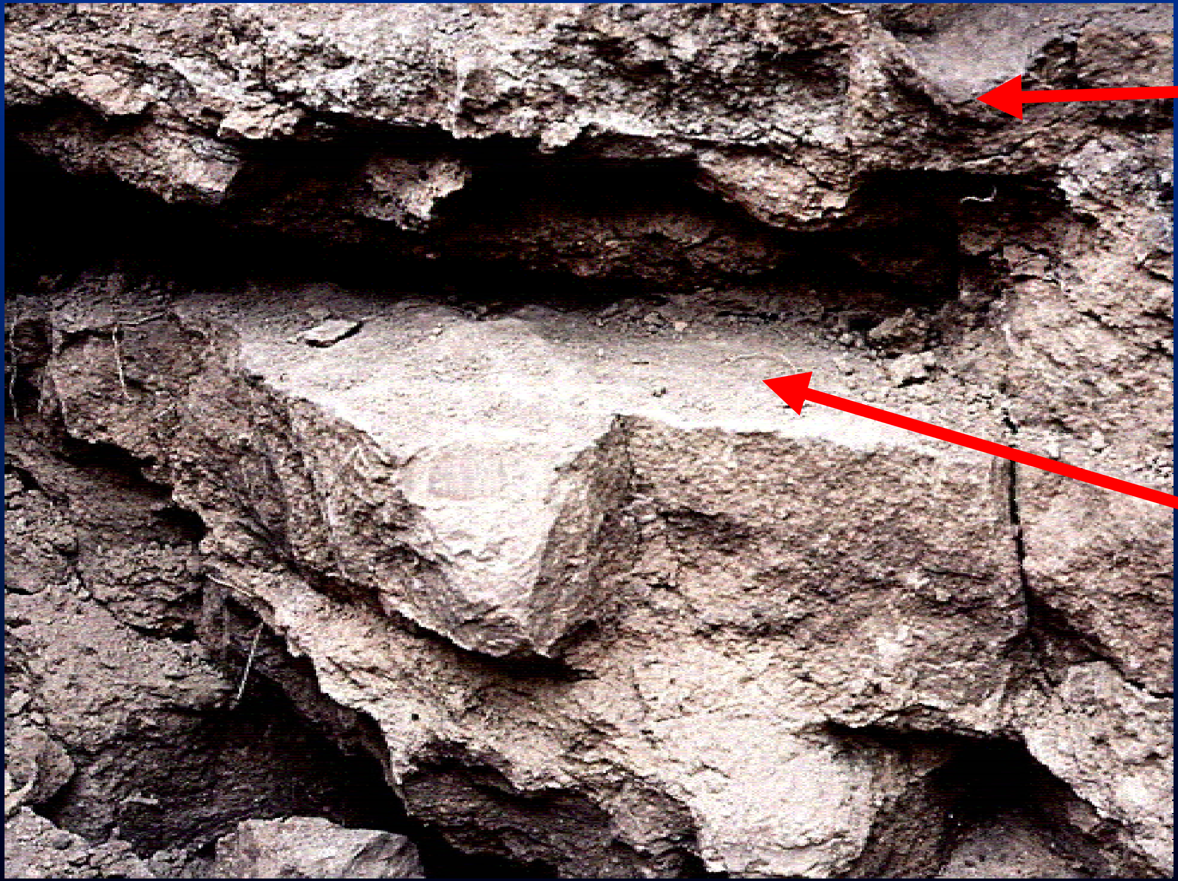
Typical Specification

- Commonly specified range of placement water content is -2 to +2 percent of Standard Proctor Optimum

Problems when too dry

- Allowing compaction 1 to 2 percent dry of optimum allows overcompaction (brittle)
- A typical clay soil can easily be compacted to 107 percent of its maximum Standard Proctor dry density if a water content of -2 % from optimum is allowed

Inflexible fill compacted dry of optimum



Imprint of Sheepsfoot Roller

Hard Discrete Lifts

Suggested Specification

- Better to specify 0 to +4 percent wet of optimum as an allowable placement water content range
- Difficult to over-compact soils at higher water contents
- But, wet soils may shrink when dry, so may not be appropriate for dry pond embankments

Embankment Cracking

Have you calibrated your nuclear gage today?

Nuclear gage is the most common method for measuring density and water content of compacted fills

NRCS Experience

- Wet Density values are reliable if gage is kept calibrated
- Water Content readings usually require calibration
- Dry Densities obtained using corrected water contents are reliable

NRCS Experience

- Nuclear meter measured water contents are usually higher than oven dry water contents
- Particularly for clay and mica rich soils.
- Nuclear meter water content readings may be lower than oven dry for loess soils

ASTM D3017

Water Content of Soil and Rock in Place by Nuclear Methods (Shallow Depth)

- Measure water content with nuclear meter
- Obtain sample at meter location and measure oven dry or microwave water content
- Compute correction factor - (equipment manual)

Importance of Corrections

- Many construction personnel are unaware of the need to evaluate this factor
- Large errors in water content result in large errors in computed dry density

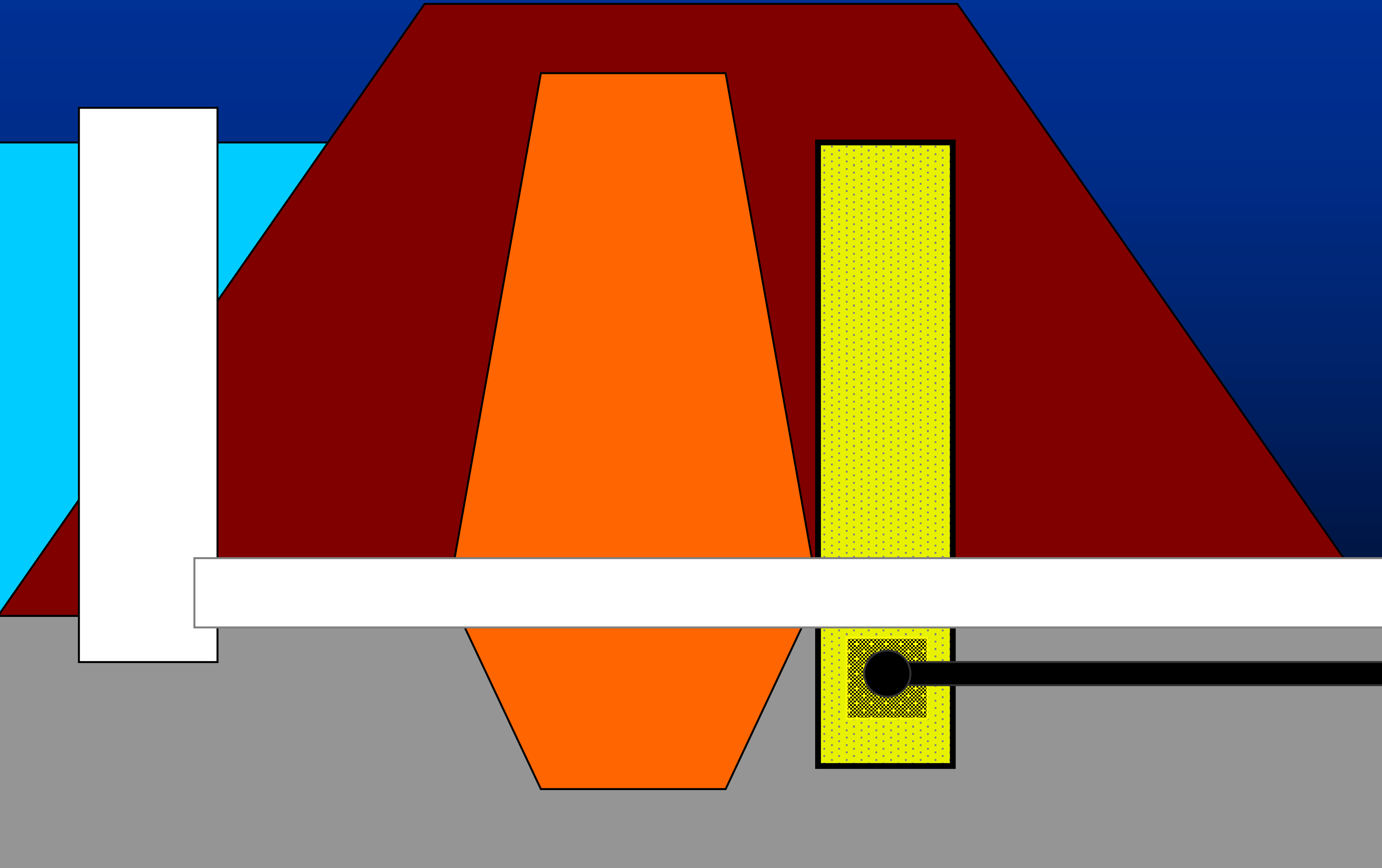
Potential Problems

- Poor calibration of equipment
- Nuclear water contents not compared to oven dry
- NRCS experience is that nuclear meter water content uncorrected for clay soils is commonly from 2-6 percent higher than oven dry water contents

Typical Incorrect Conclusions made with uncorrected w%

- Water % is 5 percent wet of optimum
- Dry Density is only 94.1 % of Maximum Dry Density
- Fill is rejected as being not dense enough
- Fill is rejected as being too wet

Filter Diaphragms



Advantages of Filter Diaphragms

- Better compaction of the fill adjacent to the conduit
- Cracks that form in the fill along the conduit will be stopped by the filter
- No formwork for anti-seep collars
- Separate diaphragm is not required if chimney drain used

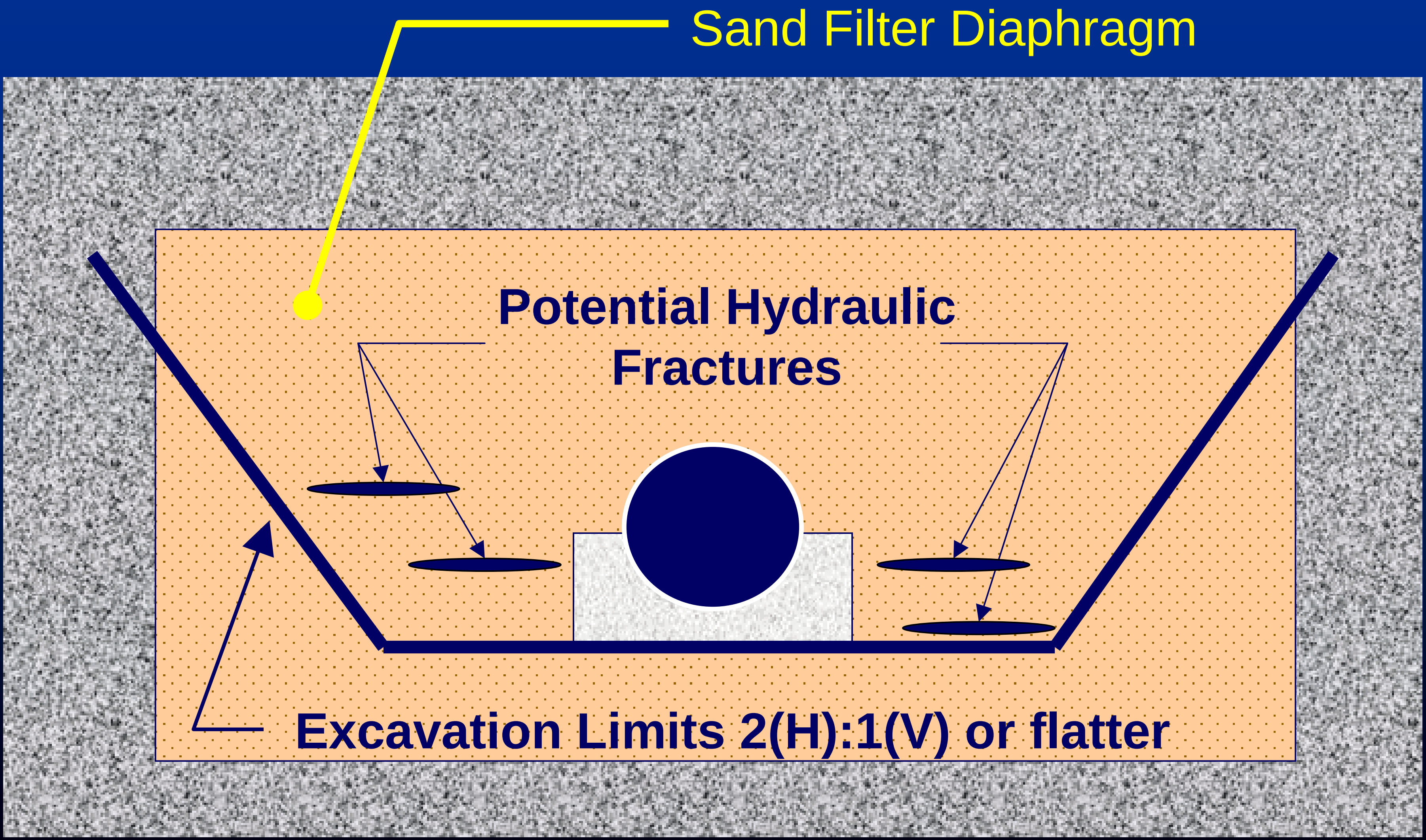
Disadvantages

- Requires careful filter design
- Compaction of the filter requires special consideration
- Many engineers are comfortable with anti-seep collars and may resist new technology

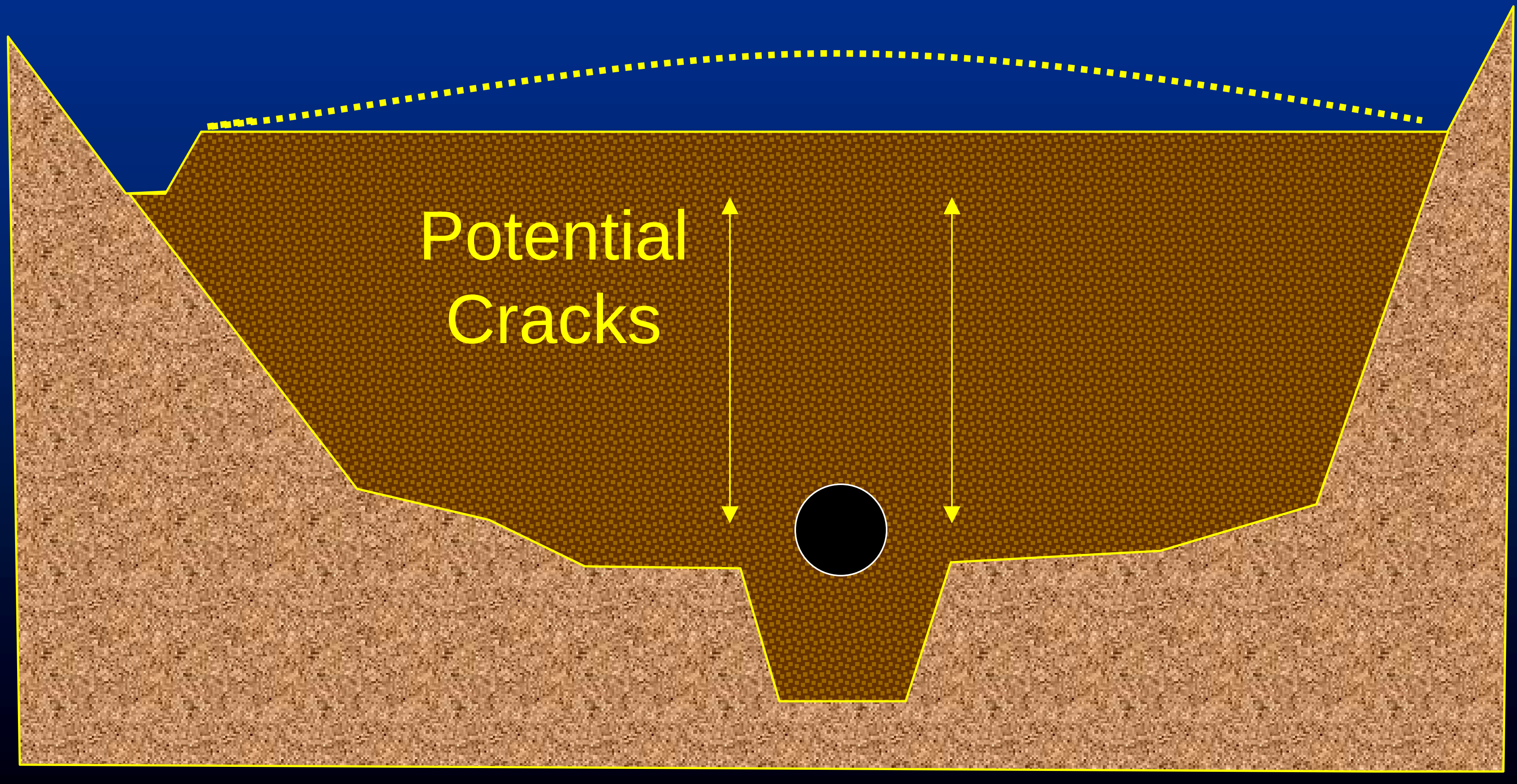
Filter Diaphragm Design

- Design for finest soil/coarsest filter combination
- Filter must be fine enough to prevent piping of the base soil without clogging, and
- Must be permeable enough to allow for seepage flow to exit quickly.
- Design guidelines on MDE “ftp” site
- ASTM C-33 sand is usually suitable for fine soils

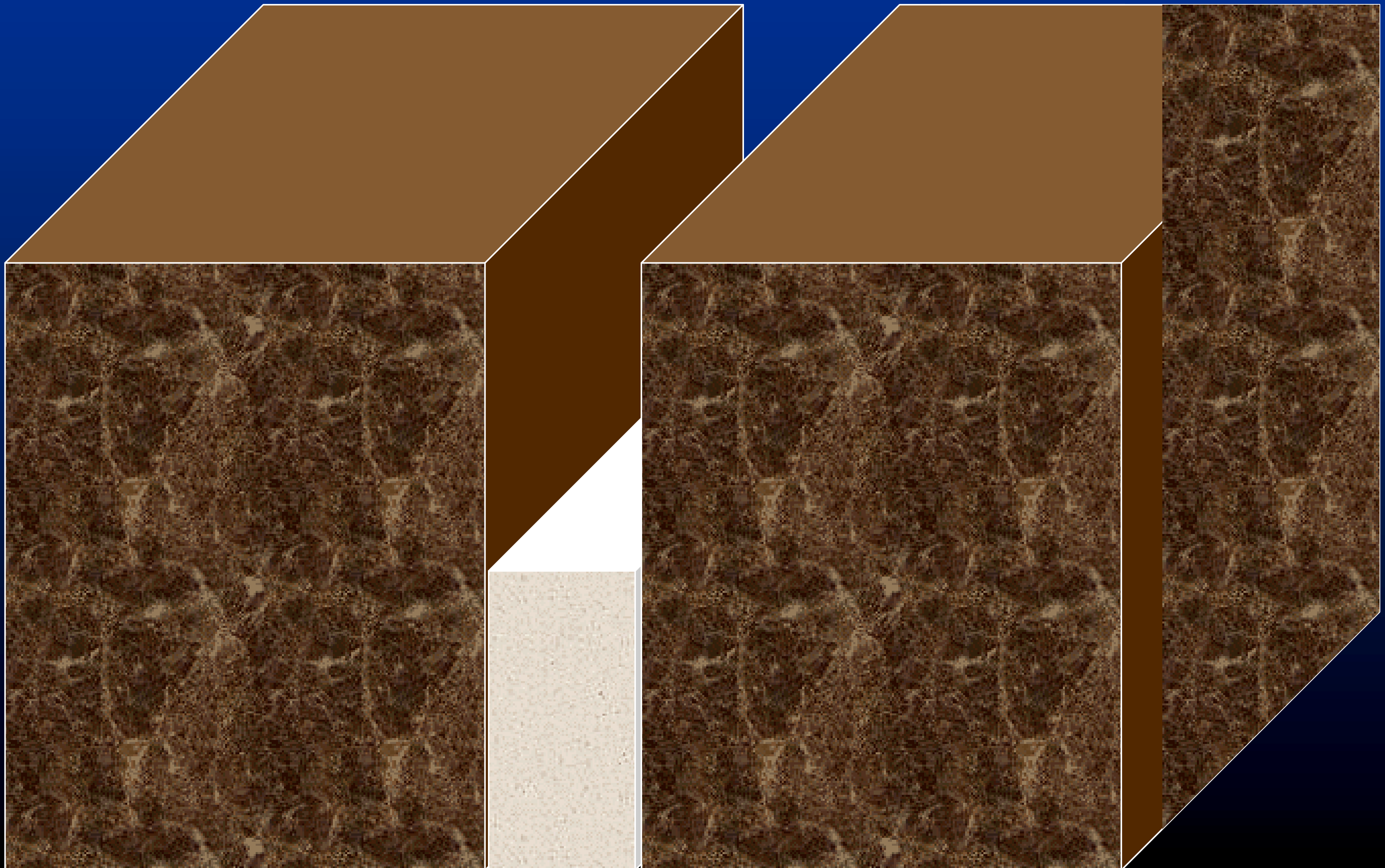
Filter diaphragm limits



Differential Settlement



Filter placement after embankment fill



Other Considerations

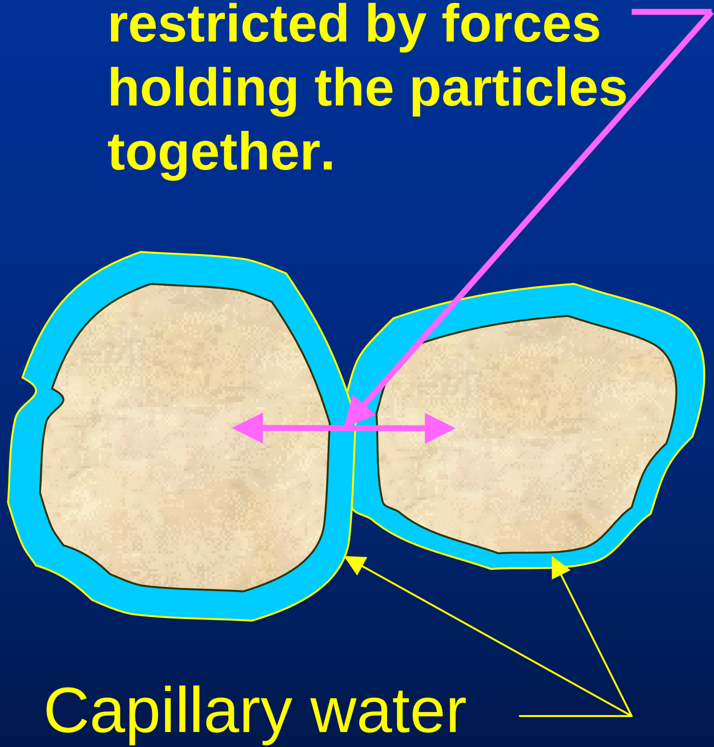
- Place filter before pipe/cradle!
- Design engineer should be involved in construction to ensure filter is compatible with actual embankment soils

PLACEMENT MOISTURE

- Placement moisture is critical for obtaining the desired density.
- Complete saturation and drainage is often best for densifying fine drainfill.
- The problem with moisture in sand and some gravels occurs at certain moisture contents when bulking occurs.

BULKING

Particle movement is restricted by forces holding the particles together.

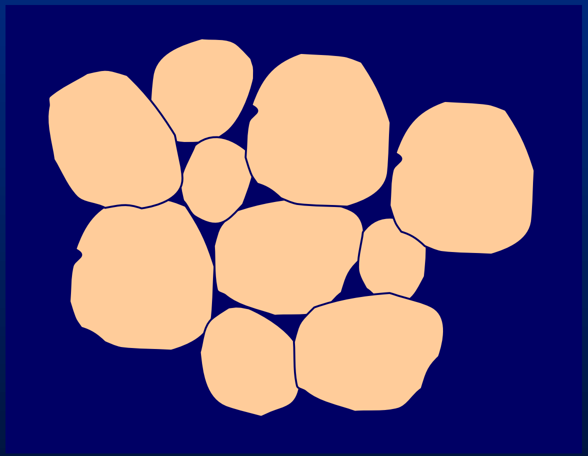


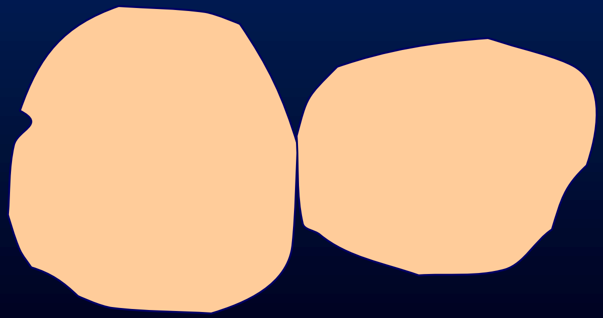
Bulking is caused by a film of capillary water on the particle surface that, when contacting other particles, tends to pull the particles together.

The particles are positioned in an uncompacted manner and it takes high compactive effort to overcome the bulking forces.

Saturation Eliminates Bulking

Complete saturation and subsequent draining of drainfill materials will cause the particles to be suspended and then resettle in a more dense state. This may be the best method for obtaining specified density.





Capillary water is removed after saturation.

Filter Suitability


23 9:44 AM


23 9:45 AM


23 9:47AM


23 9:48 AM

Concrete Pipe Spillways

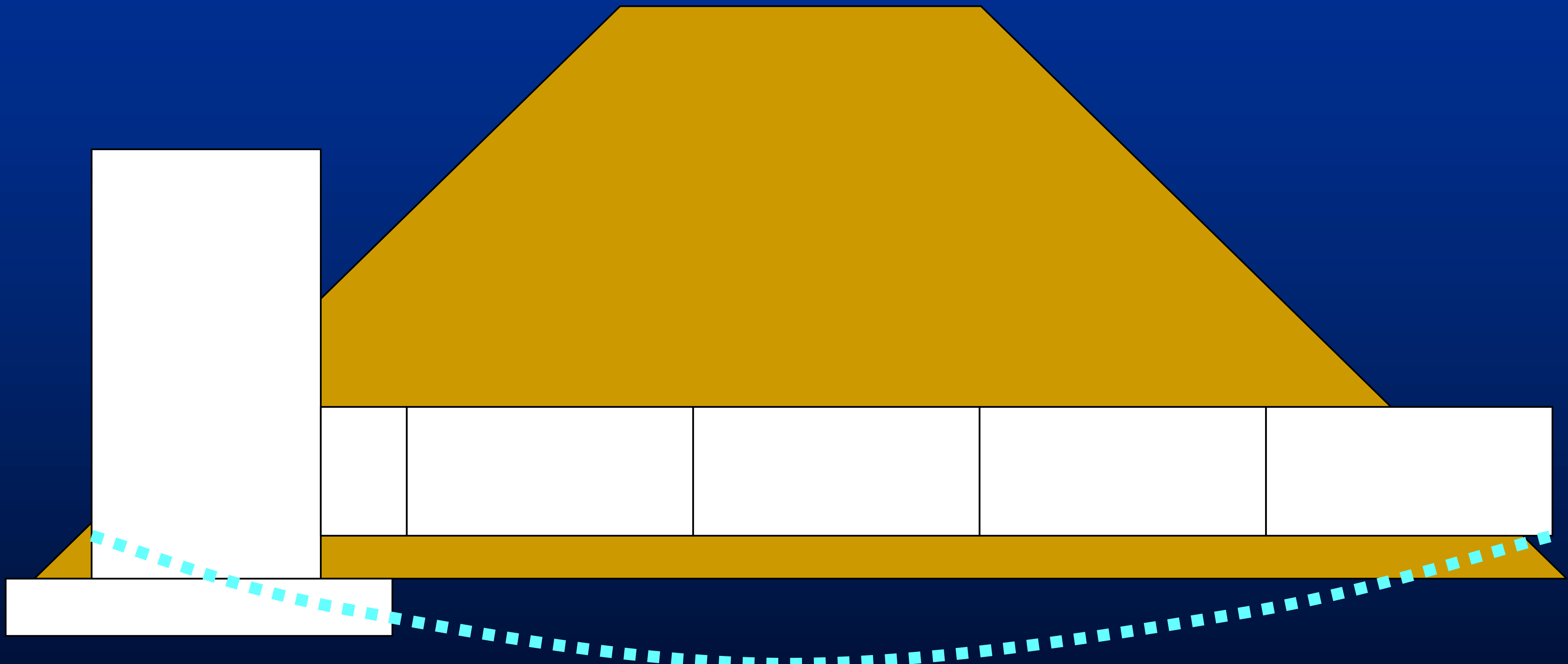
- Materials
  - ASTM C-361
  - AWWA C-300, C-301, C-304
  - Precast box culverts not acceptable
- Cradle
  - Reinforced or Unreinforced ?
- Settlement and Joint Extensibility
  - Camber ?

Concrete Pipes

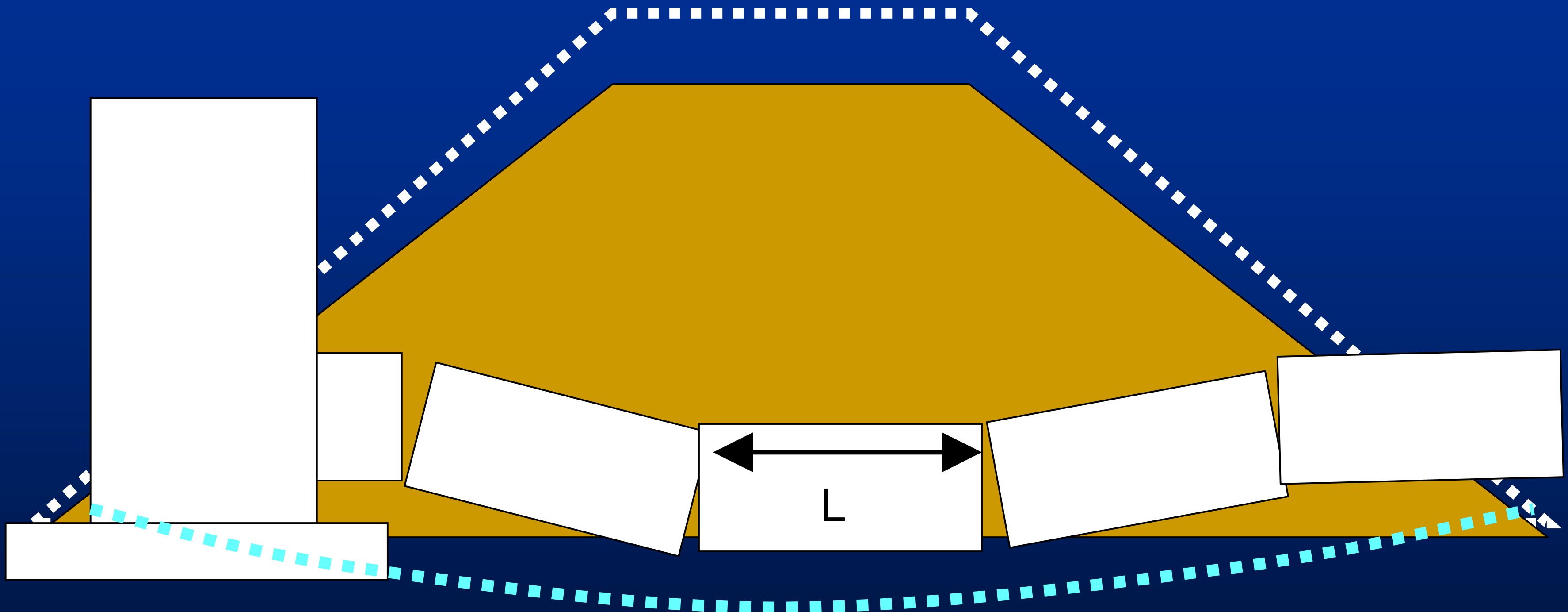
In addition to pipe standard specification, engineer should specify:

- Joint type (concrete, steel end rings, etc)
- Gasket type
- Amount of joint extensibility
- Cradle details

Joint Extensibility



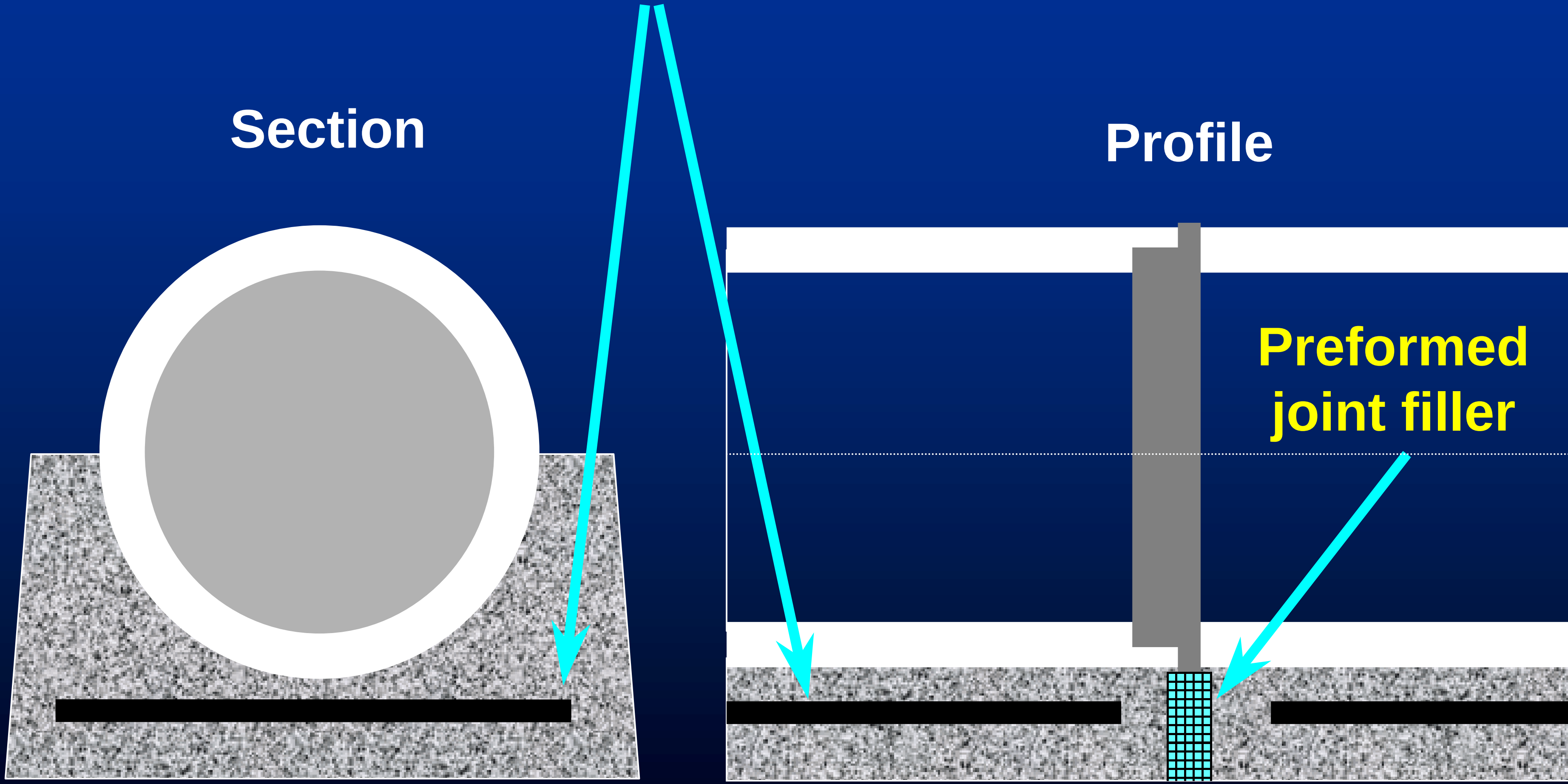
Joint Extensibility



40 ft dam on soft foundation with one foot settlement.

Each pipe joint may open 1.5 inches (L=20 ft)

Reinforcement not continuous across pipe joints



Other Considerations

- Require as-built certifications at end of sediment control phase
- Design engineer should be involved in construction
- Design not done until structure is complete

Ice Lenses (ML soils)

Cold