ENVIRONMENTAL GEOTECHNICS
MKAJ 1083

TOPIC 5: COMPACTED SOIL LINER

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FACTORS FOR MATERIAL SELECTION

- Hydraulic conductivity
- Strength
- Potential for shrinkage with moisture content

Guide for selection of liner material

Likelihood of volume change with change in moisture content	*PI* (%)	*SL* (%)
Little	0 – 30	12 or more
Little to moderate	30 – 50	10 – 12
Moderate to severe	>50	10 and less

Index Properties vs Volume Changes

Colloid content (<0.001 mm) (%)	*PI* (%)	*SL* (%)	Estimated expansion (% tot vol from dry to Saturated condition under 1 psi pressure)
> 28	> 35	< 11	> 30 (very high)
20 – 31	25 – 41	7 – 12	20 – 30 (high)
13 – 23	15 – 28	10 – 16	10 – 20 (med)
< 15	< 18	> 15	< 10 (low)

Requirements by USEPA for clay liners

1) At least 20% fines (fine silt and clay-size particles)

2) The plasticity index (*PI*) should be greater than 10.

3) The soil should not include more than 10% gravel-size particles.

4) The soil should not contain any particles or chunks of rock that are larger than 25mm to 50mm.

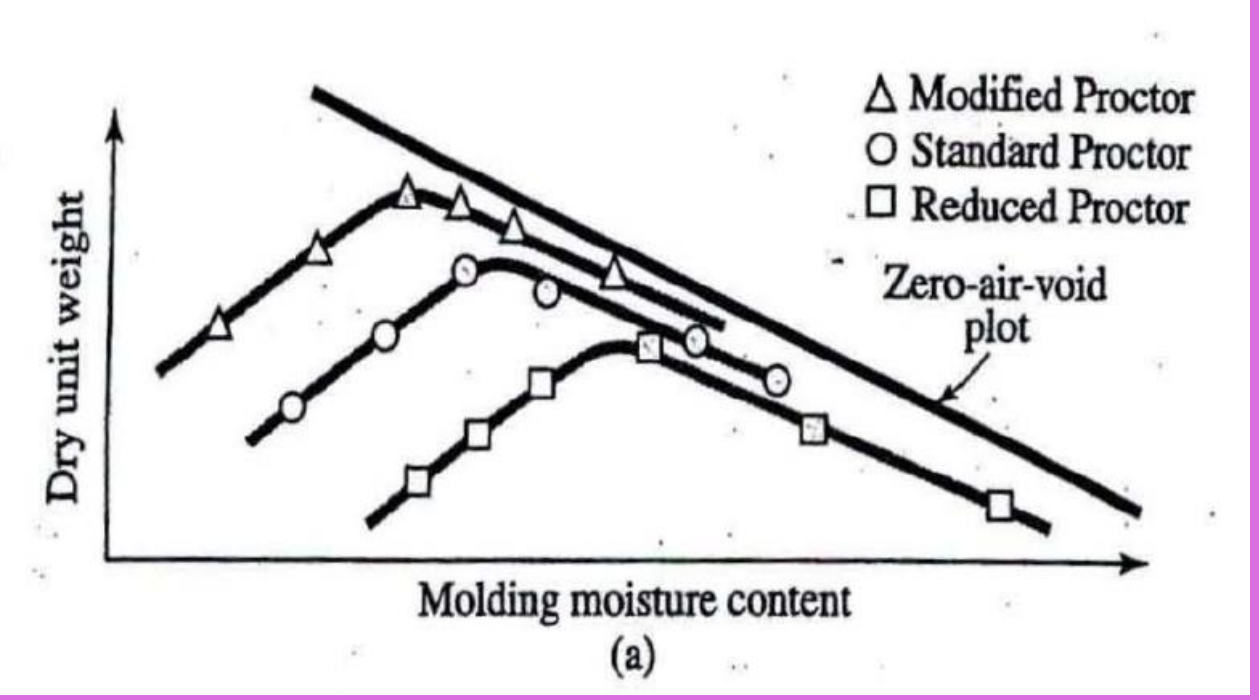
Requirements: Hydraulic Conductivity, k

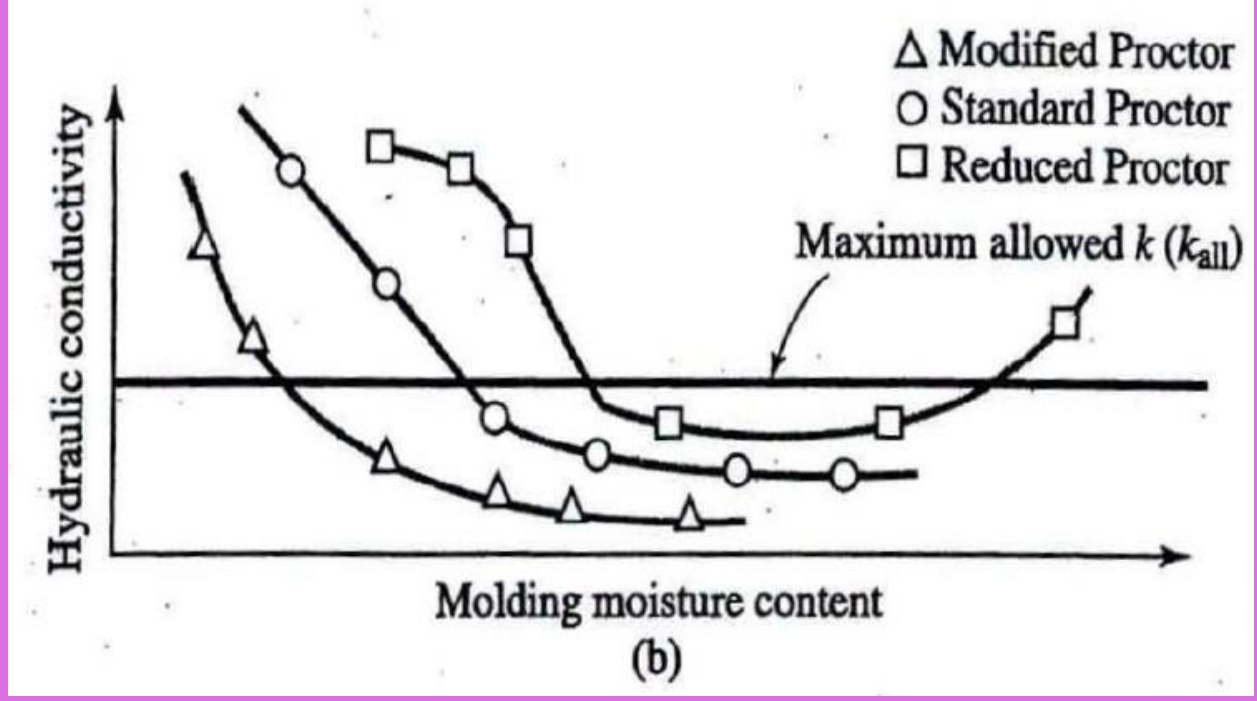
1) Conduct modified, standard and reduced Proctor tests to establish dry unit weight– w

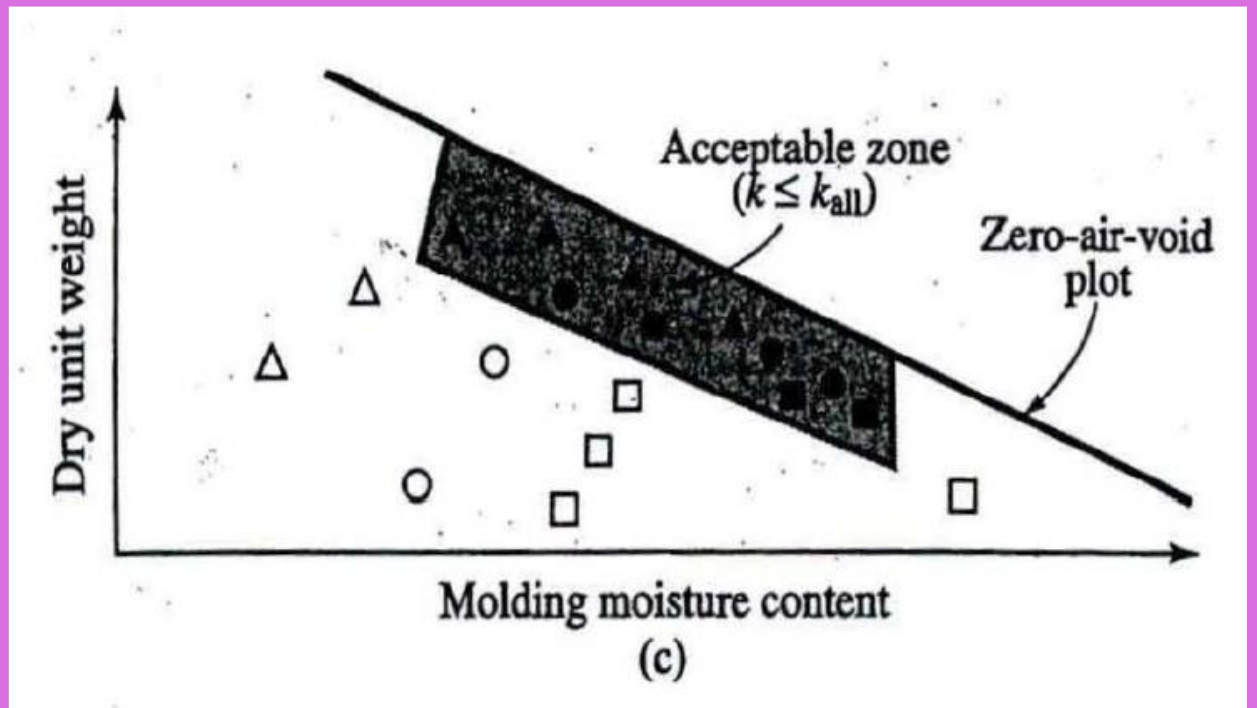
2) Conduct permeability tests on the compacted soil specimens from step 1 and plot the results. Plot also the maximum allowable value of k ($kall$)

3) Replot the $\gamma d - w$ with different symbols to represent the compacted specimens with $k > kall$ and $k \leq kall$

4) Plot the acceptable zone for which k is less than or equal to $kall$.


Modified Proctor
Standard Proctor
Reduced Proctor
Zero-air-void plot
Dry unit weight
Molding moisture content
(a)


Modified Proctor
Standard Proctor
Reduced Proctor
Maximum allowed k (k_{all})
Hydraulic conductivity
Molding moisture content
(b)


Acceptable zone
($k \leq k_{all}$)
Zero-air-void plot
Dry unit weight
Molding moisture content
(c)

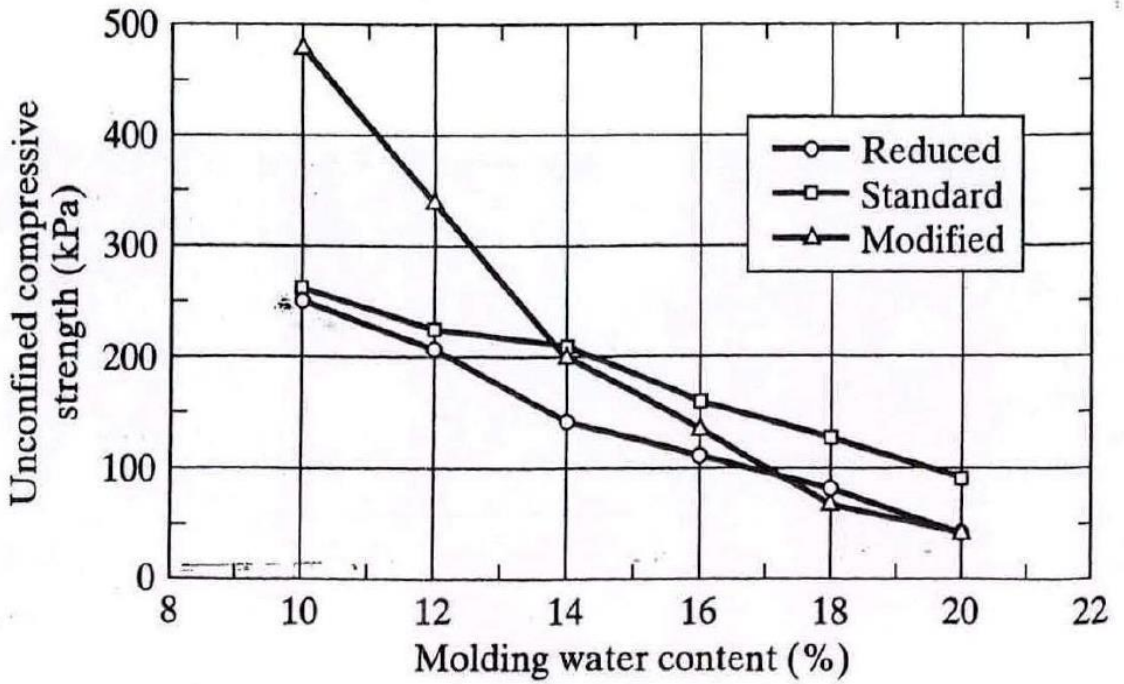
Requirements: Strength

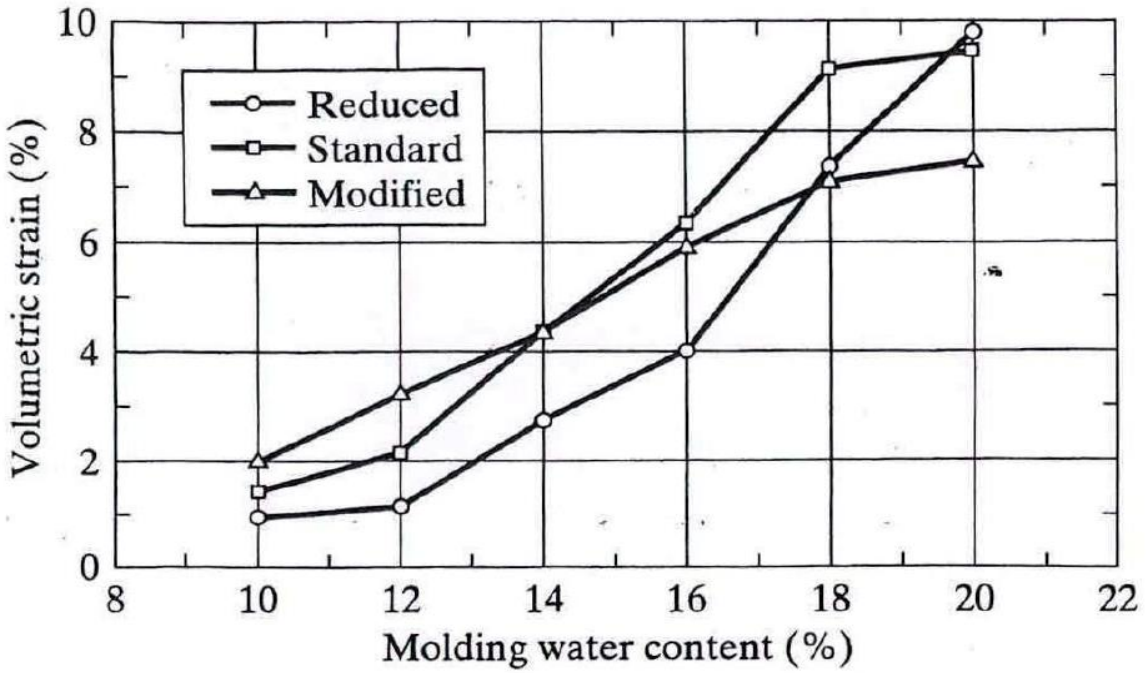
i) Develop compaction curves

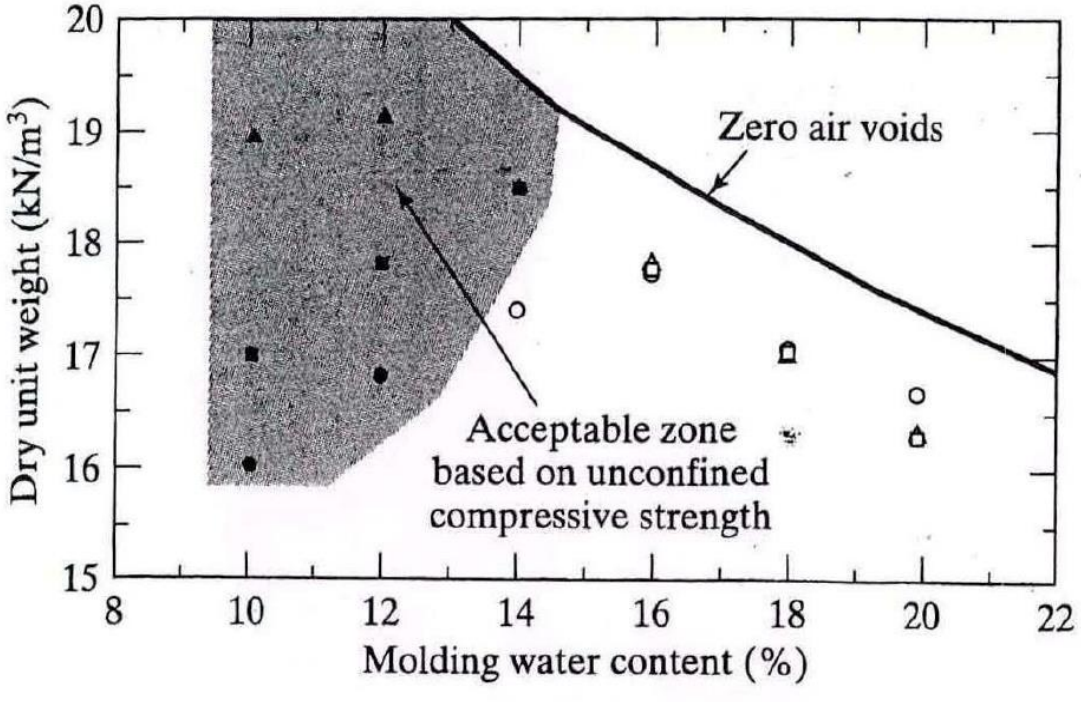
ii) Plot the measured shear strength (based on UCT or UU test) as a function of molding water content.

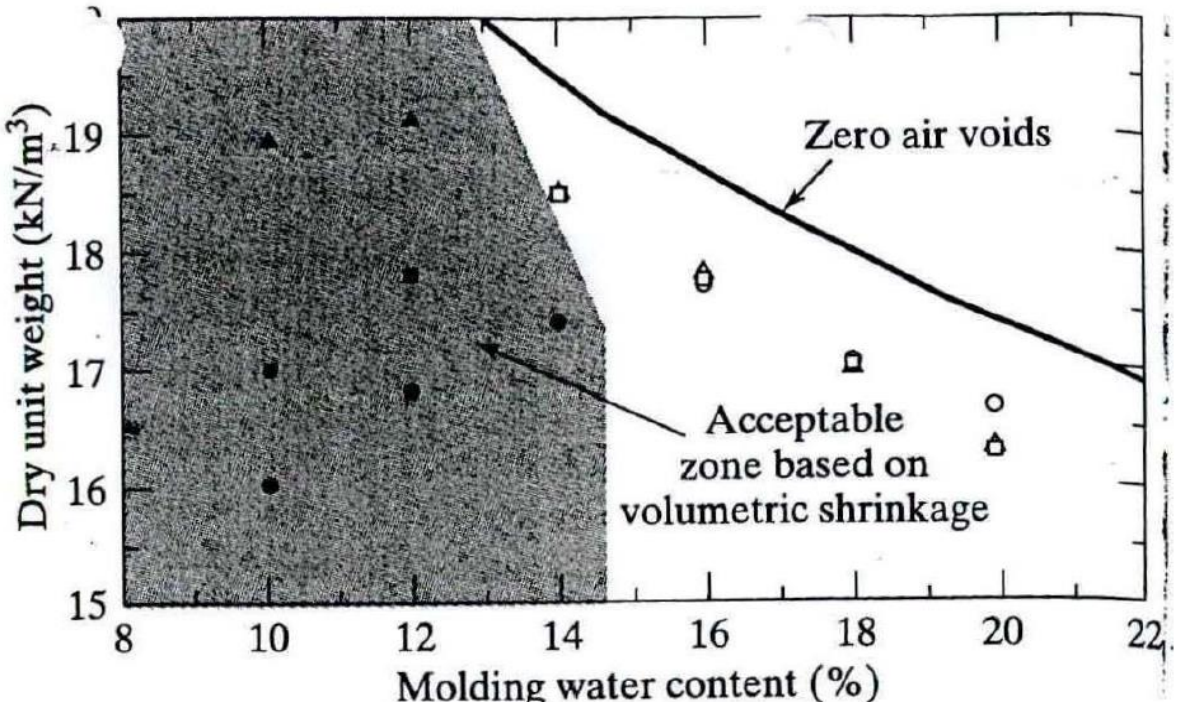
iii) The dry unit weight and water content points are replotted with different symbols used to represent compacted specimen that meet the strength requirement.

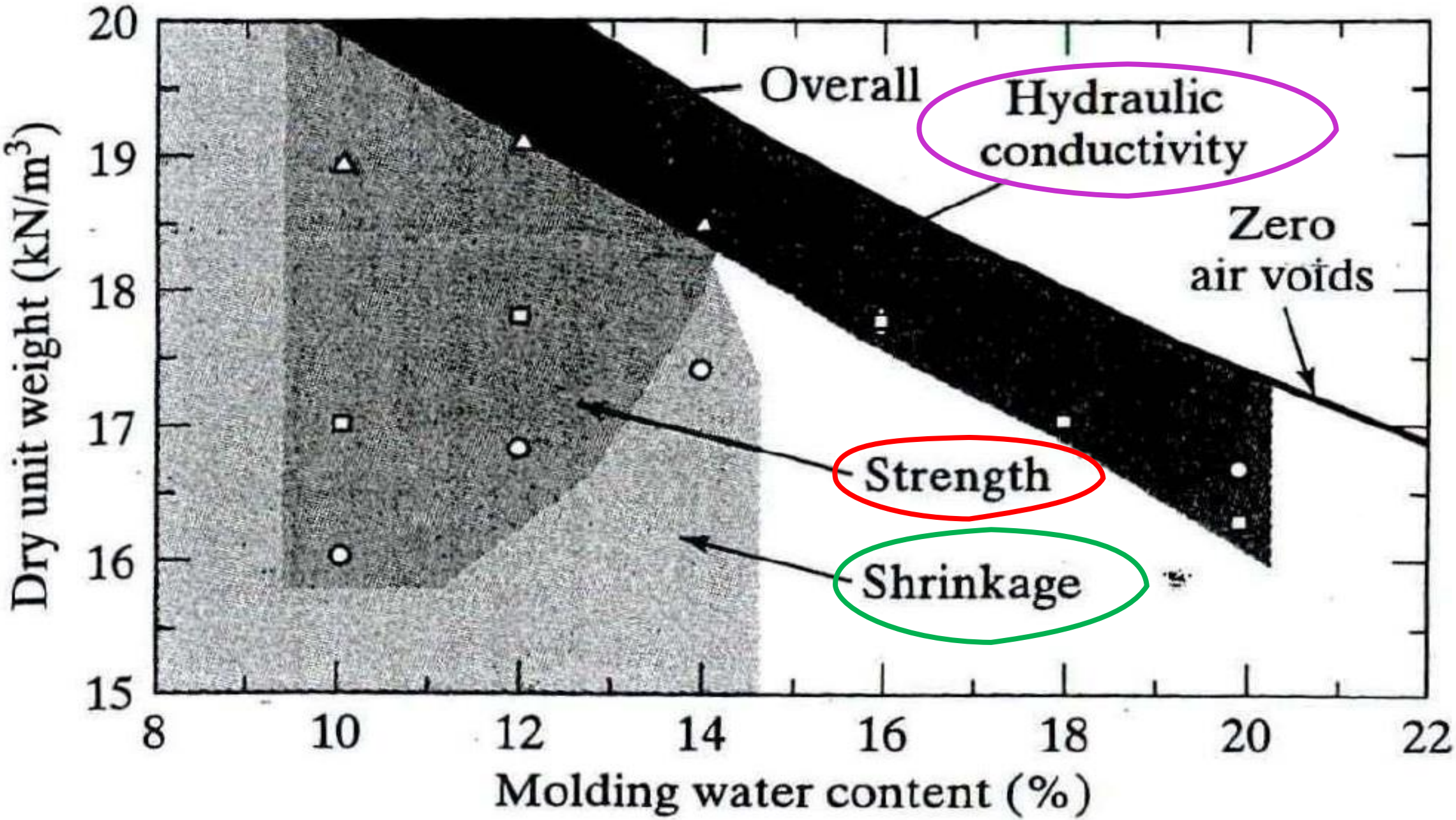
$$C_w / C_{wopt} = \exp[-5.8(w - w_{opt}) / PI]$$


Unconfined compressive strength (kPa)
500
400
300
200
100
0
8
10
12
14
16
18
20
22
Molding water content (%)
Reduced
Standard
Modified


Volumetric strain (%)
10
8
6
4
2
0
8
10
12
14
16
18
20
22
Molding water content (%)
Reduced
Standard
Modified


Dry unit weight (kN/m³)
20
19
18
17
16
15
8
10
12
14
16
18
20
22
Molding water content (%)
Zero air voids
Acceptable zone based on unconfined compressive strength

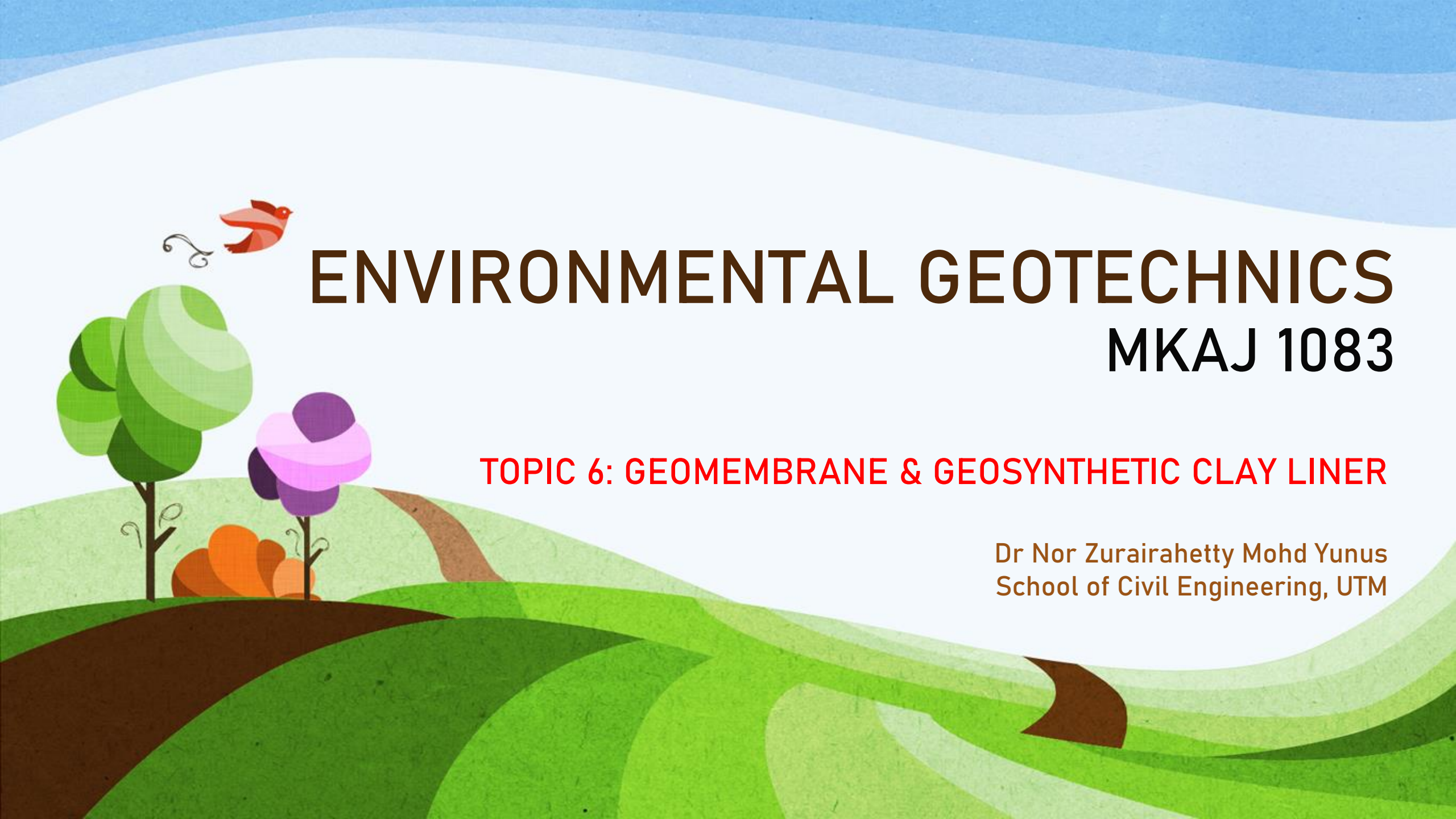

Dry unit weight (kN/m³)
19
18
17
16
15
8
10
12
14
16
18
20
22
Molding water content (%)
Zero air voids
Acceptable zone based on volumetric shrinkage



Acceptable zone in terms of strength, shrinkage and hydraulic conductivity

CCLs: ADVANTAGES

- Popular; more demand
- Availability of clay in large quantities
- Puncture proof; large thickness
- Reasonable quality assurance
- Increases break through time by diffusion



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TOPIC 6: GEOMEMBRANE & GEOSYNTHETIC CLAY LINER

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GEOMEMBRANE

high density polyethelene (HDPE)

very low density polyethelene (VLDPE)

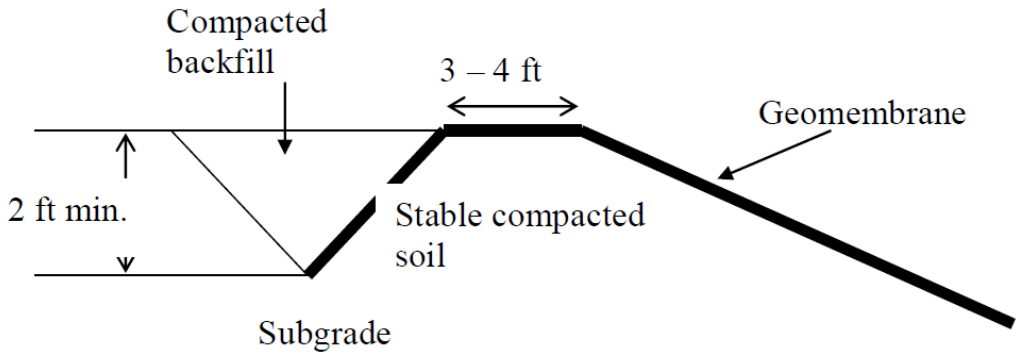
polyvinyl chloride (PVC)

chlorosulfonated polyethelene with fabric reinforcement (CSPE-R)

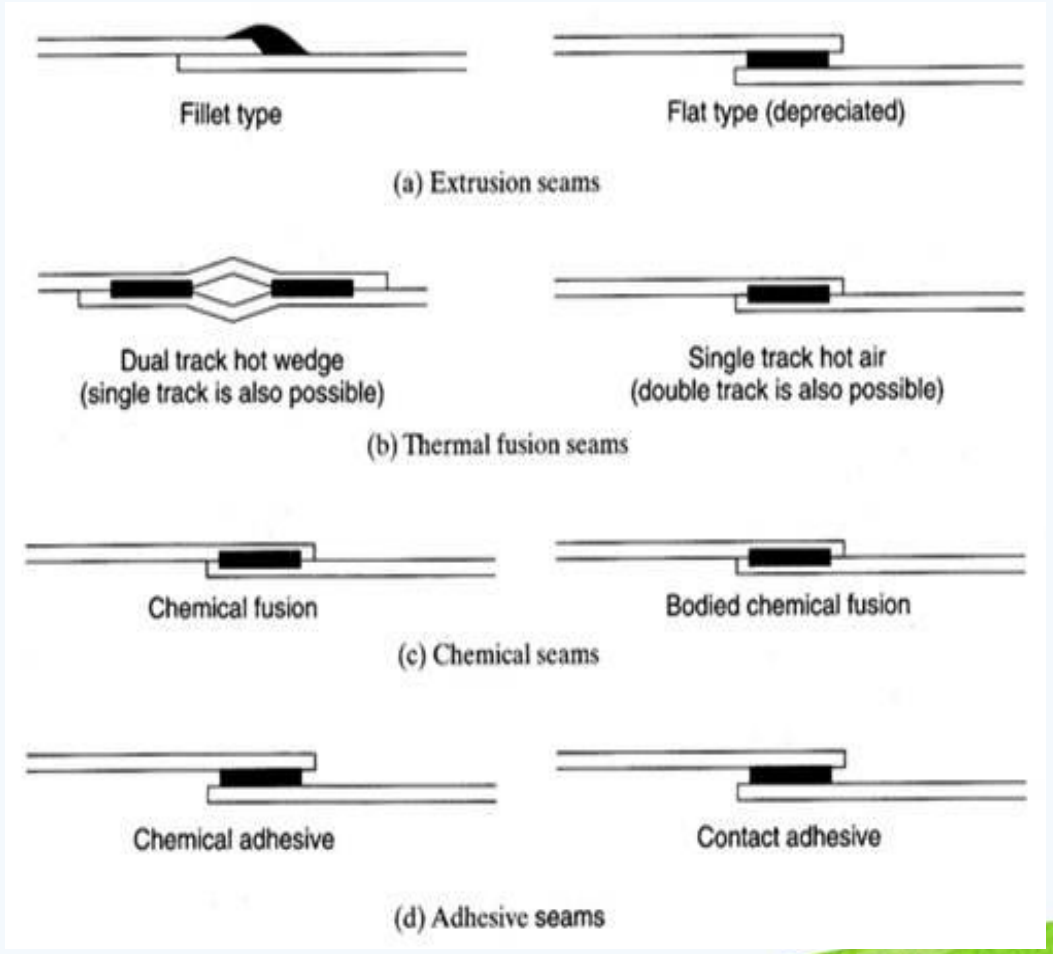
CHARACTERISTICS OF GEOMEMBRANE

- Physical Properties
- Sensitivity to organic liquids and vapors
- Sensitivity to temperature
- Creep (changing in dimension)
- Stress cracking
- Resistant to biodegradation
- May be subjected to microbial attack

GEOMEMBRANE: Placement & Seaming



Anchor trench



GEOSYNTHETIC CLAY LINER (GCLs)

- thin layer 4 – 6 mm (usually sodium bentonite) is supported by geotextiles or geomembranes
- Reinforced GCL offers higher shear resistance compared to GCL without reinforcement.
- The hydraulic conductivity of intact GCL is low (10-8 to 10-9 cm/s)

TABLE 5.4 Differences between Compacted Clay Liners and Geosynthetic Clay Liners (after USEPA, 1993)

Characteristic	Compacted Clay Liner	Geosynthetic Clay Liner
Materials	Native soils or blend of soil and bentonite	Bentonite clay, adhesive, geotextile, and geomembrane
Construction	Construction in the field	Manufactured and then installed in the field
Thickness	Approximately 2 to 3 ft (600 to 900 mm)	Approximately 0.5 inches (13 mm)
Hydraulic conductivity	$\leq 1.0 \times 10^{-7}$ cm/sec	$\leq 1.0 \times 10^{-9}$ to 5.0×10^{-9} cm/sec
Availability of materials	Suitable materials not available at all sites	Materials easily shipped to any site
Speed and ease of construction	Slow, complicated construction	Rapid, simple installation
Vulnerability to damage during construction as a result of desiccation	CCLs are nearly saturated. CCLs can desiccate during construction and crack severely. CCLs can produce consolidation water	GCLs are essentially dry. GCLs cannot desiccate during construction, but there can be problems with overlap width for some GCLs. GCLs produce no consolidation water
Ease of quality Assurance	Complex QA procedures, requiring highly skilled and knowledgeable people	Relatively simple, straight-forward, common-sense procedures
Cost	Highly variable, estimated range: $0.50 to $5.00 per square foot	Typically $0.42 to $0.60 per square foot for a large site
Experience Level	Has been used for many years	Limited

GCLs: ADVANTAGES

- Small thickness; conserve landfill space
- Construction; rapid and simple
- Can be shipped anywhere
- Installation; do not need heavy equipment, less vehicular traffic (leads to less air pollution)
- Water is not necessary during construction
- Consistent material can be produced (manufactured material)
- Withstand freeze/thaw and wet/dry cycles
- Less settlement (light material)


thank you so much