Embankment Dam Committee E Workshop

Standard Proctor water content variation

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Standard Proctor Water Variance Specification

Water content variance from Optimum (%)	Application	Zone of Earthfill Dam
0 to 2	Impervious earthfill Materials	Core
-1 to 3	Semi-pervious earthfill Materials	Outer Zone

Embankment Dam Committee E Workshop

1 **Introduction**

- Location of core and outer zones of a zoned earthfill dam
- Definition of semi-pervious and impervious earthfill materials
- Water content variance specification

2 **Standard Proctor Compaction Test Definition**

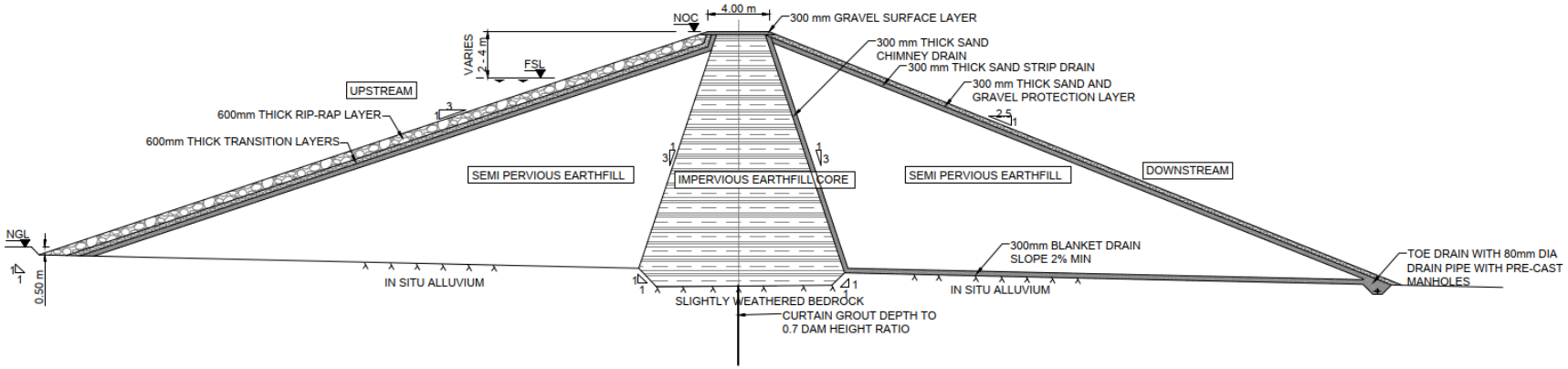
3 Specification of Water content variation

4 **Driekloof Dam shear strength testing**

- Results

5 **Conclusions**

Core and Outer Zone Materials



TYPICAL CROSS SECTION THROUGH
EARTHCORE EARTHFILL DAM
SCALE 1:150

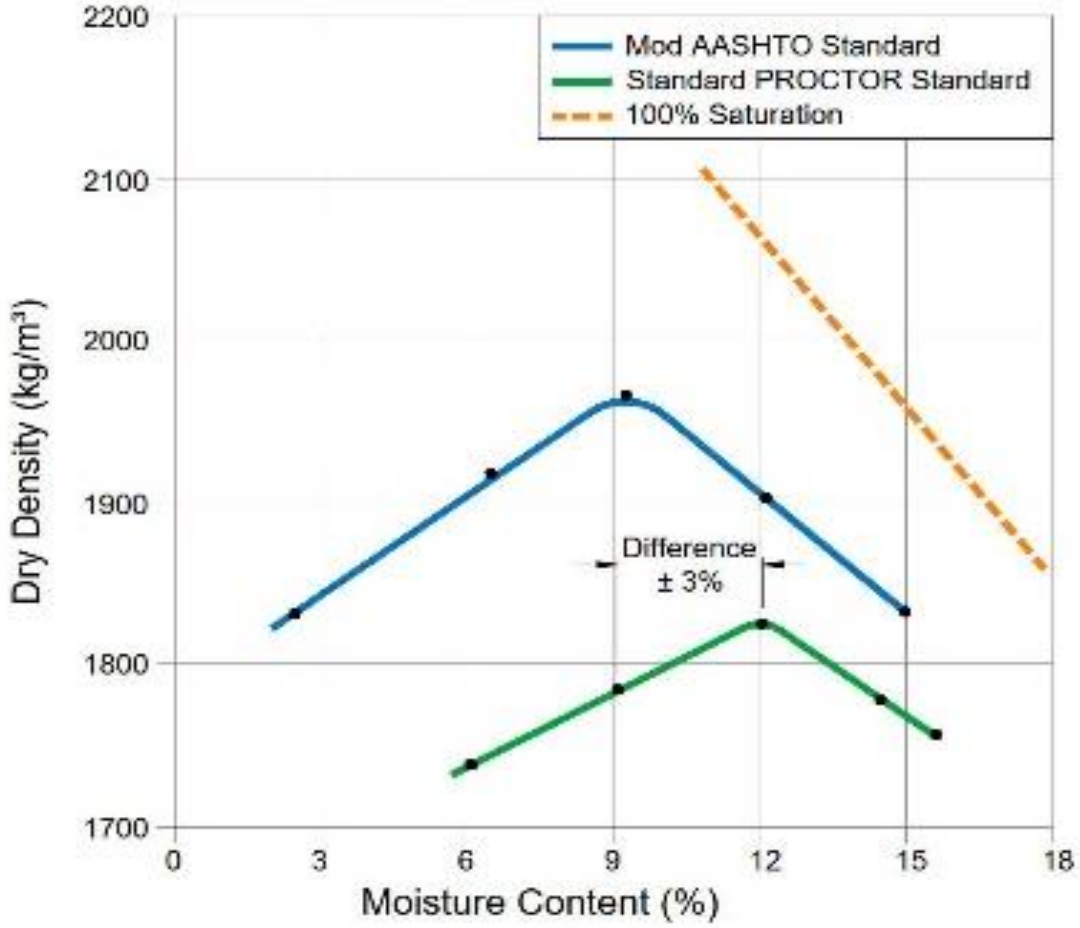
Definition of Impervious and Semi-pervious Earthfill Materials

Geomechanical Property	Zone of earthfill dam	
	Core (Impervious materials)	Outer Zones (Semi-pervious Materials)
Grading	> 60% through 0.42 sieve	> 40% through 0.42 sieve
Clay content (CC) (%)	10<CC<30	CC<10
Liquid Limit (LL) (%)	30<LL<60	LL<30
Plasticity Index (PI)	12<PI<35	4<PI<12.5
Linear Shrinkage (LS) (%)	40<LS<10	7<LS<0
Maximum Dry Density (MDD) (kg/m^3)	1 450<MDD<1 880	1 750<MDD<2 100
Optimum Water Content (w) (%)	14<w<25	6<w<16
Shear strength (^{o})	18<Phi'<30	28<Phi'<38
Cohesion (C) (kPa)	12<C'<24	C'<12
Permeability (k) (cm/s)	k<10^{-04}	K>10^{-04}

Design for a seal (Core) in an embankment dam

- Elasticity is important to prevent cracking
- Casagrande study showed compaction by Standard Proctor facilitate this
- Elasticity in core more important than in outer zones

Compaction Standards

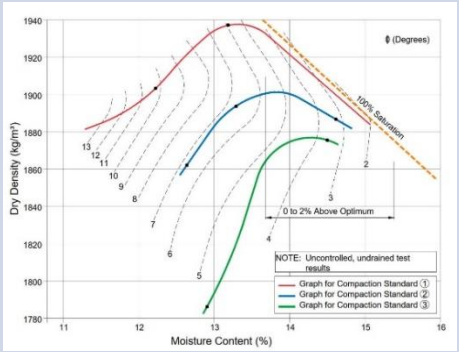
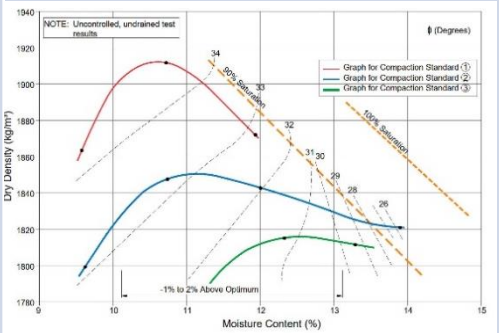
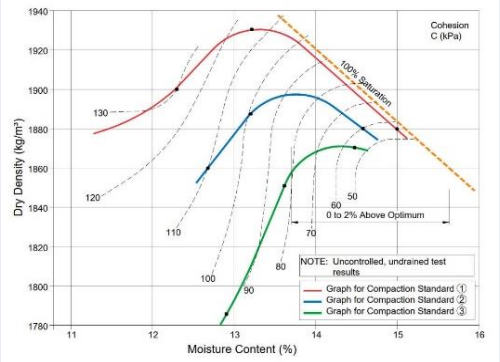
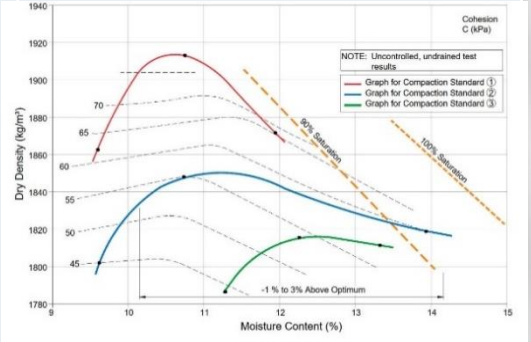


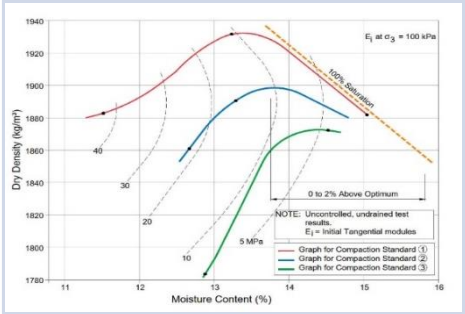
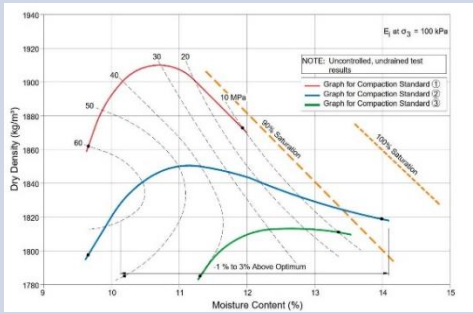
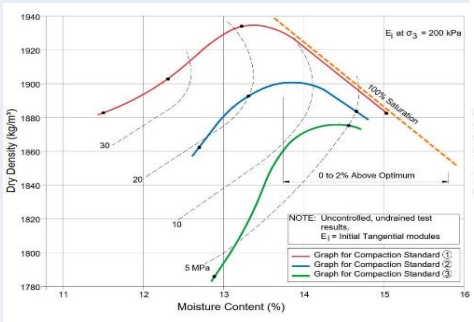
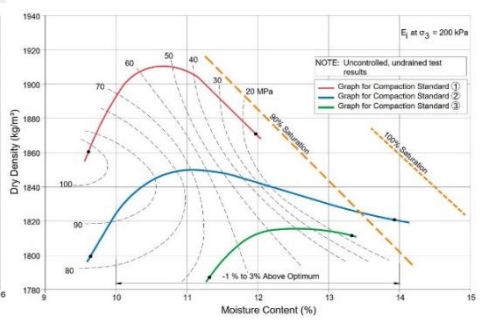
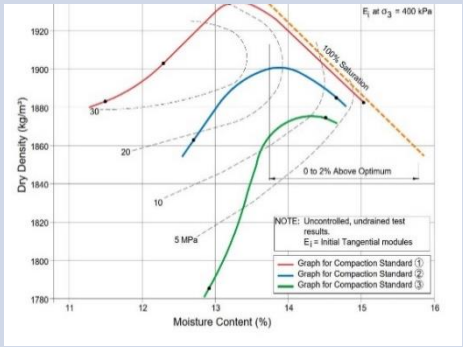
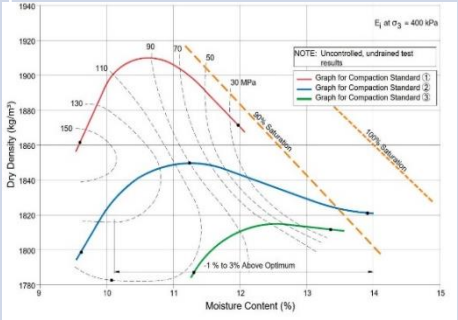
Test references and Details

Test	Reference	Mould diameter (mm)	Hammer mass (kg)	Fall height of hammer (mm)
Standard Proctor	ASTM D698 AASHTO T99	100	2.5	304
Modified AASHTO or Modified Proctor	D1557, AASHTO T180	100	4.54	457.2

Driekloof Dam in South Africa

Laboratory triaxial shear strength testing with volume change of soil samples

Property	Impervious Earthfill	Semi-pervious Earthfill
Phi		
C		

Property	Impervious Earthfill	Semi-pervious Earthfill
Ei 100KPa		
Ei 200kPa		
Ei 400Kpa		

Geomechanical characteristics for water content variance

Property	Water content variance (%)	
	0<w<2 (Impervious Earthfill)	-1<w<3 Semi-pervious Earthfill
Shear Strength (Phi) (Degrees)	1 to 8	30 to 33
Cohesion (C) (kPa)	+-30 to 90	52 to 55
Ei Modulus (MPa) (Sigma 3 = 100 kPa)	2 to 10	10 to 62
Ei Modulus (MPa) (Sigma 3 = 200kPa)	2 to 15	15 to 92
Ei Modulus (MPa) (Sigma 3 = 400kPa)	2 to 25	20 to 135

Placement 0%<w<2% (Impervious core earthfill)	**Placement -1%<w<3% (Semi-pervious outer zone earthfill)**
Shear strength Phi and C vary more – but not so important for Embankment slope stability	Shear strength Phi and C variation is low which is important for Embankment slope stability
Ei varies very little and less than for semi-pervious materials. (no cracking of core)	Significant variance more than for impervious soils on Ei. Elasticity less important for outer zones.

From the above the following can be concluded:

- The Standard Proctor compaction standard should be used for compaction of earthfill in embankment dams.
- As zoning for earthfill embankment dams into a central core and outer zones with impervious and semi-pervious earthfill used in the respective zones, the variation of water content during compaction of the zone materials into 0% to 2% and -1% to 3% of the optimum water content for the respective core and outer zones, **provides the required geomechanical parameters for earthfill**; and
- provided the basis at Driekloof Dam for a design **meeting elasticity and no cracking requirements.**

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SANCOLD

Thank you