Chapter 8

Material Characterization

Material Characterization

Purpose:

- to understand material behavior
- construction control
- material properties for design(h= f (material))
- pavement evaluation
- establish failure criteria

Types of tests:

- Arbitrary: CBR, Stability....
- Fundamental: Triaxial, Diametral...
- Full Scale: AASHTO road test, ...

Requirement:

- establish properties: Test....
- Failure criteria: Fatigue, rutting, deformation, serviceability...

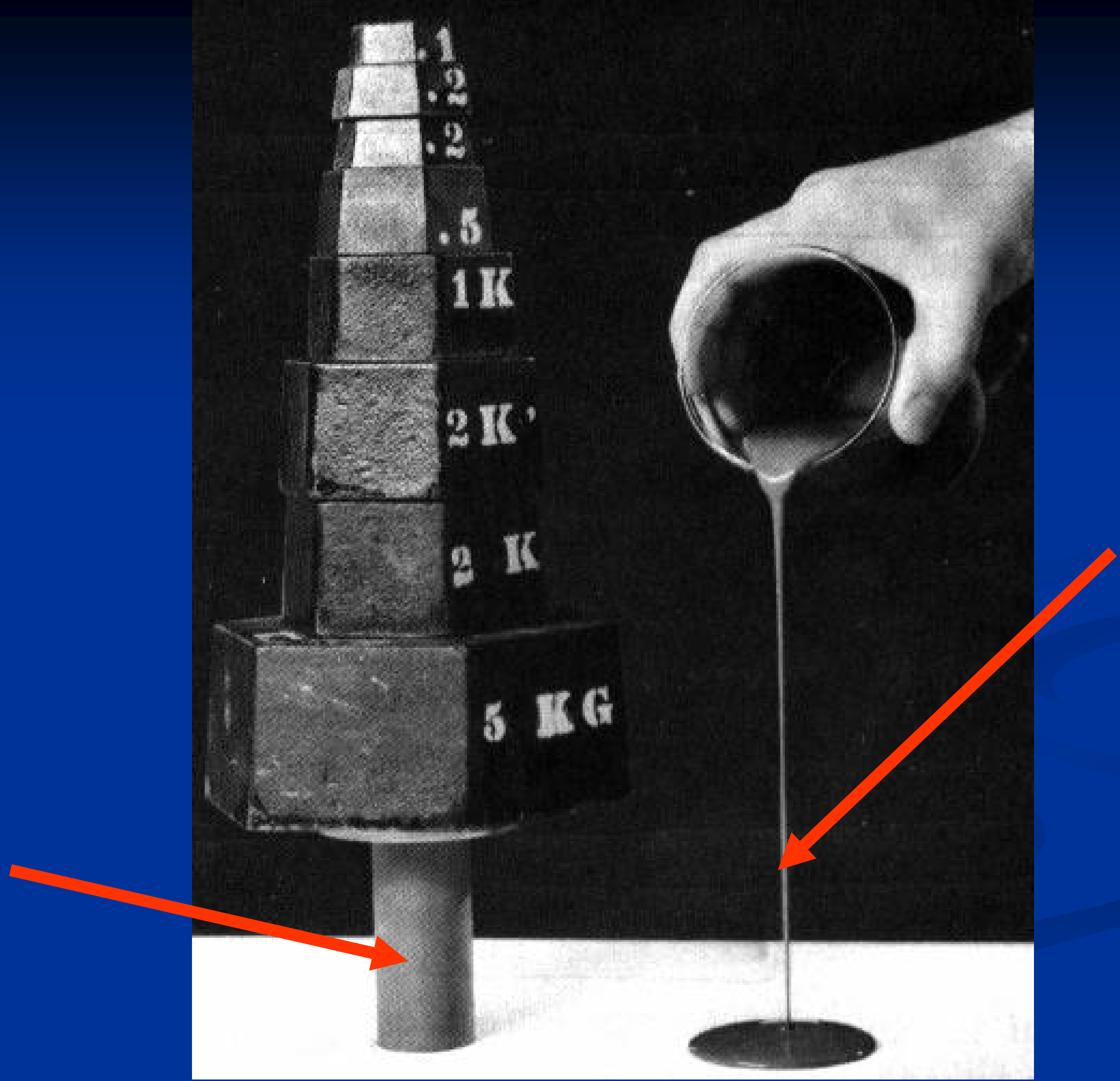
Material Testing

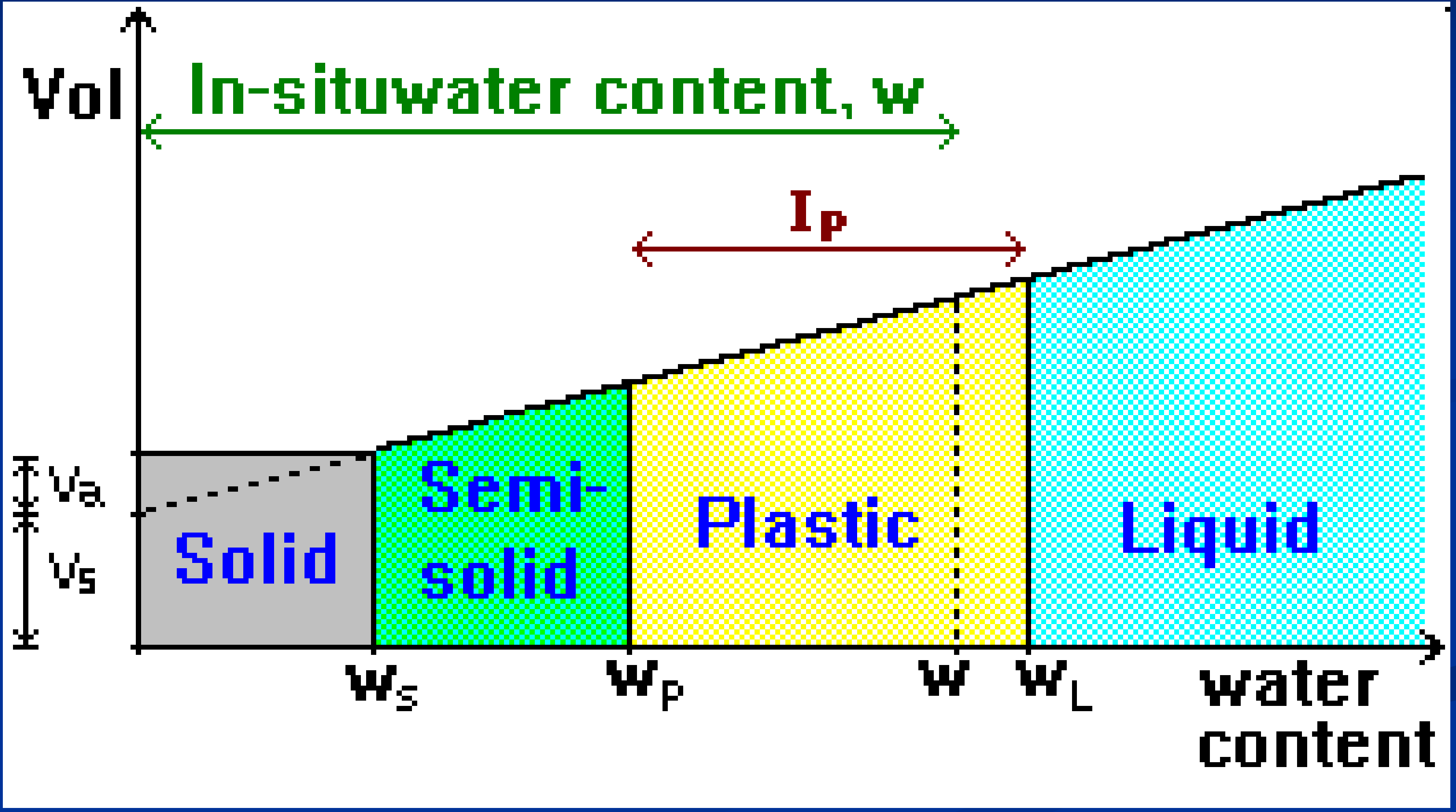
soils and granular materials:

- soil classification
- subgrade support (plate bearing, k)
- California bearing ratio (CBR)
- Static triaxial test (ϕ, angle of internal friction, C, cohesion and τ, shear)
- Dynamic triaxial test (permanent deformation, resilient modulus (Mr) for fine and coarse materials and poisons ratio (μ))

Bituminous materials testing:

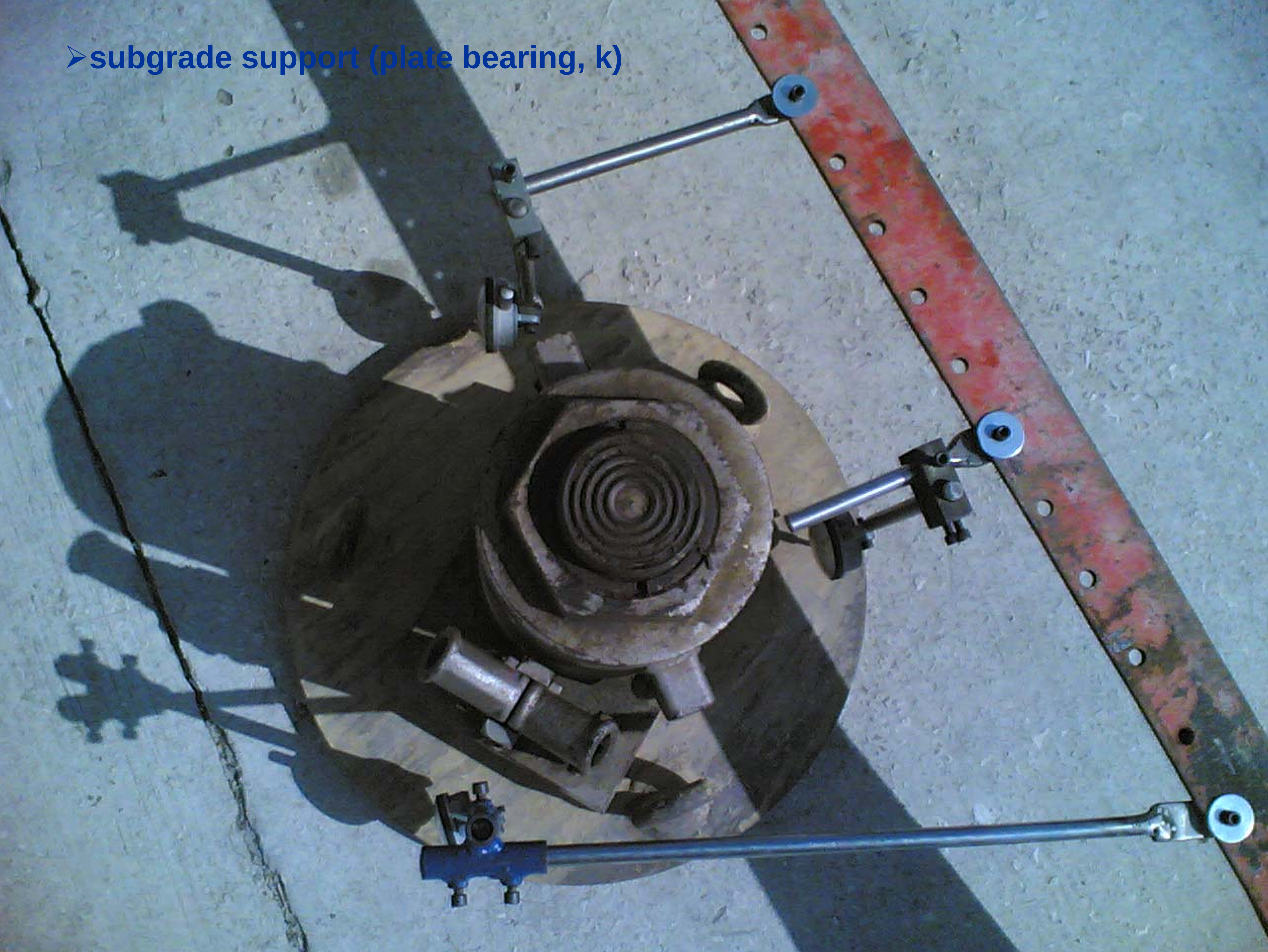
- Marshall test
- SuperPave
- Modulus of rupture, MR
- indirect tensile test, ITS or σ_T
- Diametral test, resilient modulus,Mr
- Dynamic triaxial, resilient modulus,Mr, poisons ratio (μ)and permanent deformation
- complex dynamic modulus, E*


.1
.2
.2
.5
1 K
2 K
2 K
5 KG



Vol
In-situwater content, w
Ip
Va
Vs
Solid
Semi-solid
Plastic
Liquid
ws
wp
w
wL
water content

- **subgrade support (plate bearing, k)**

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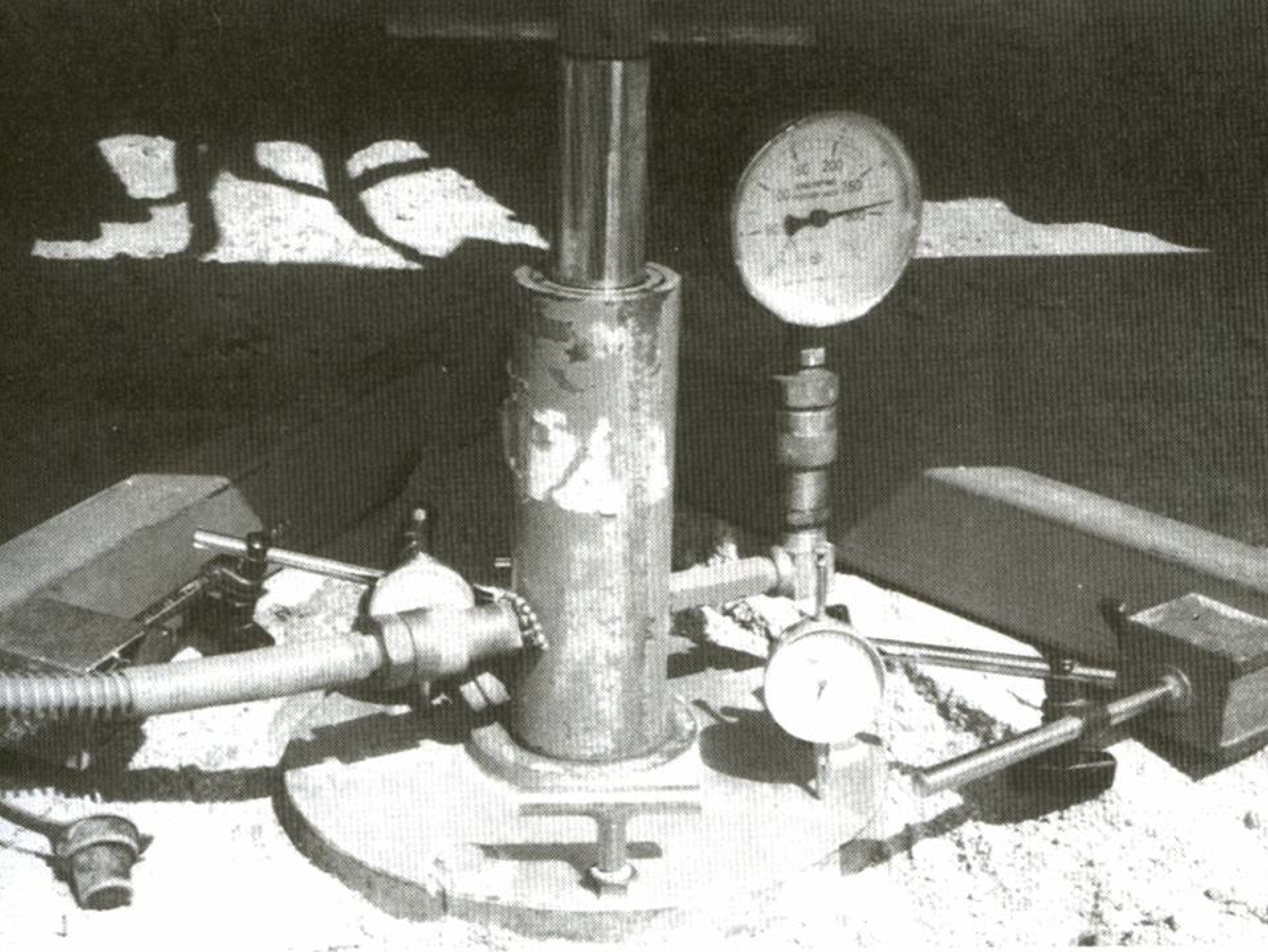
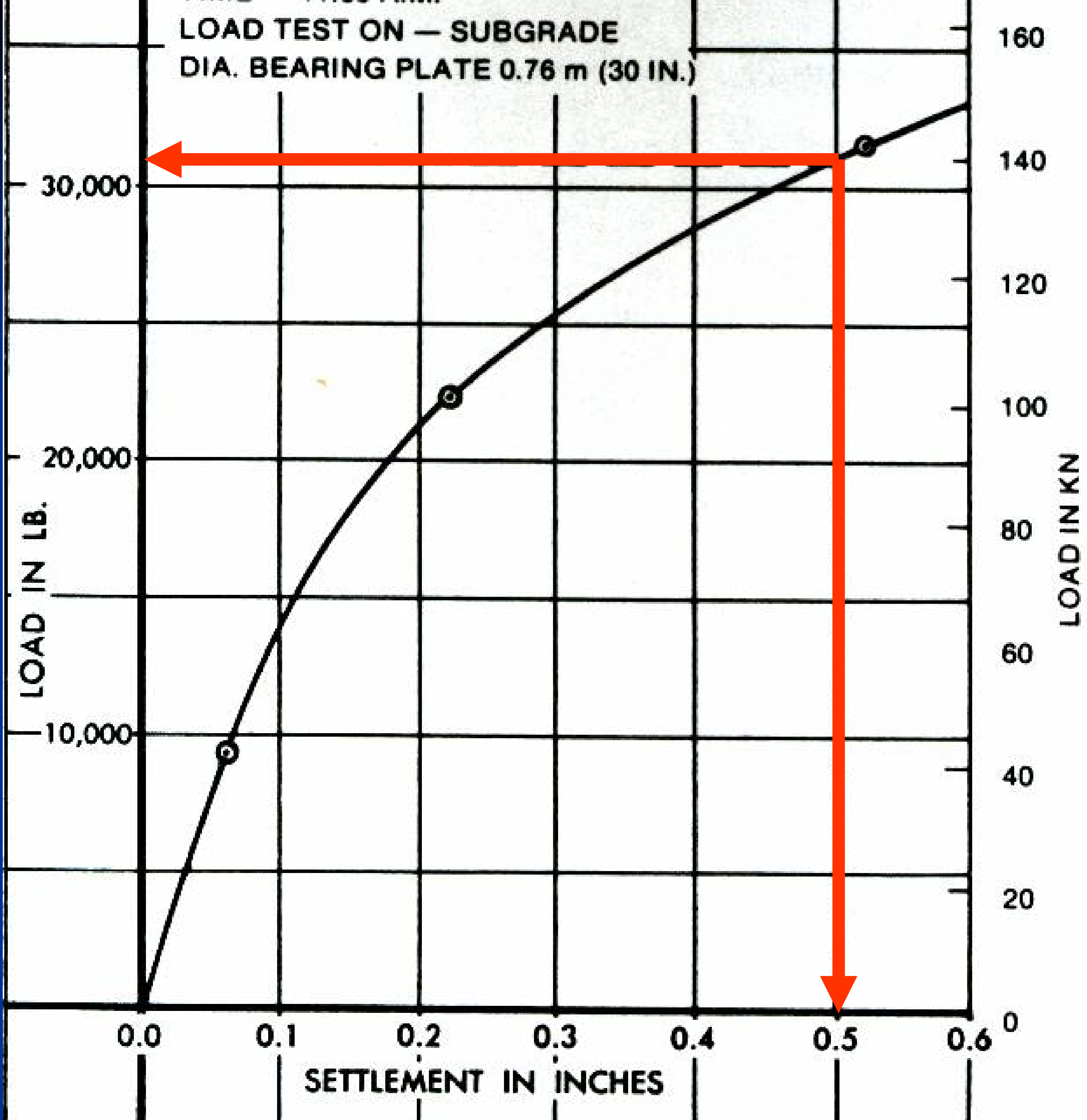
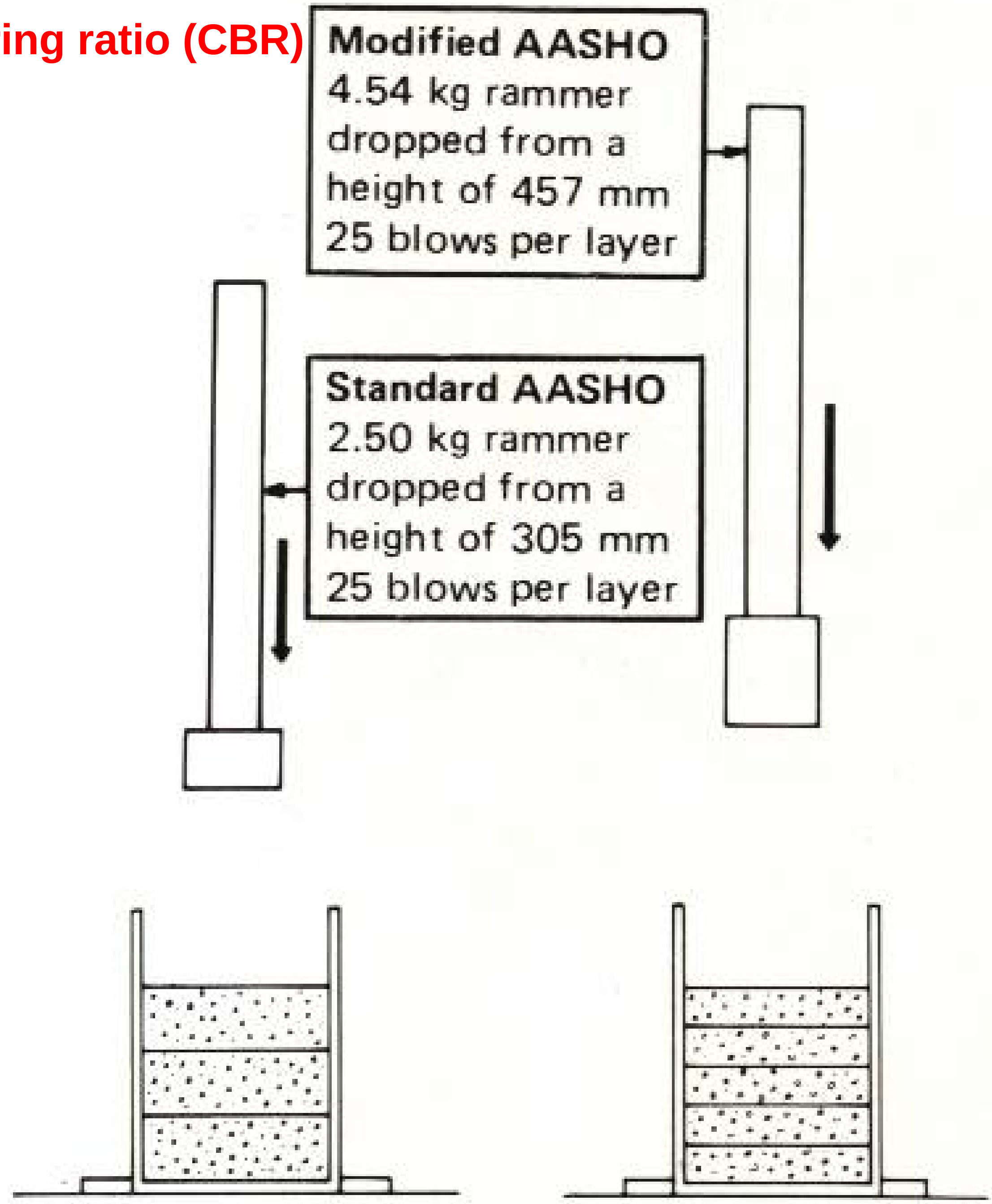
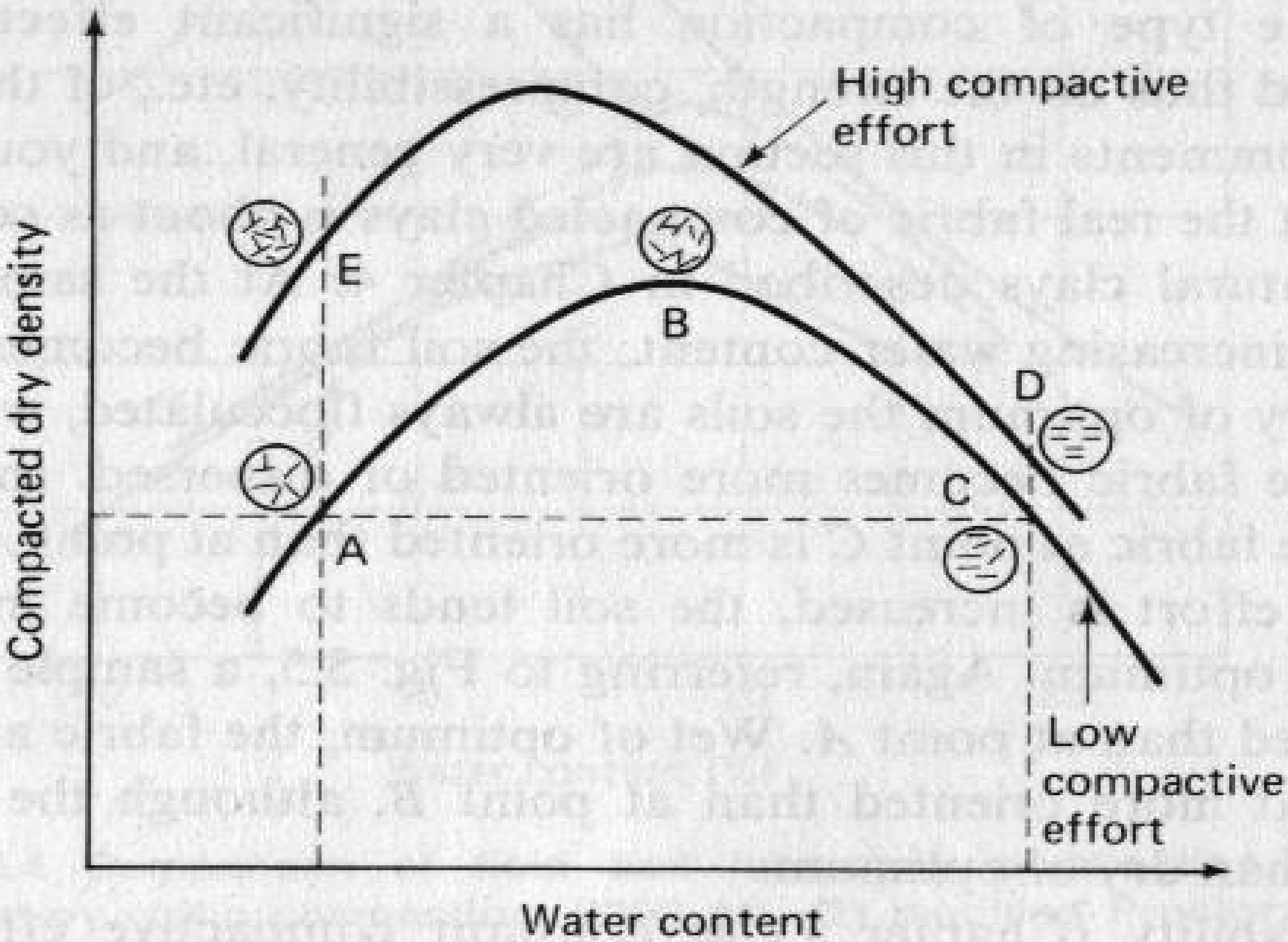


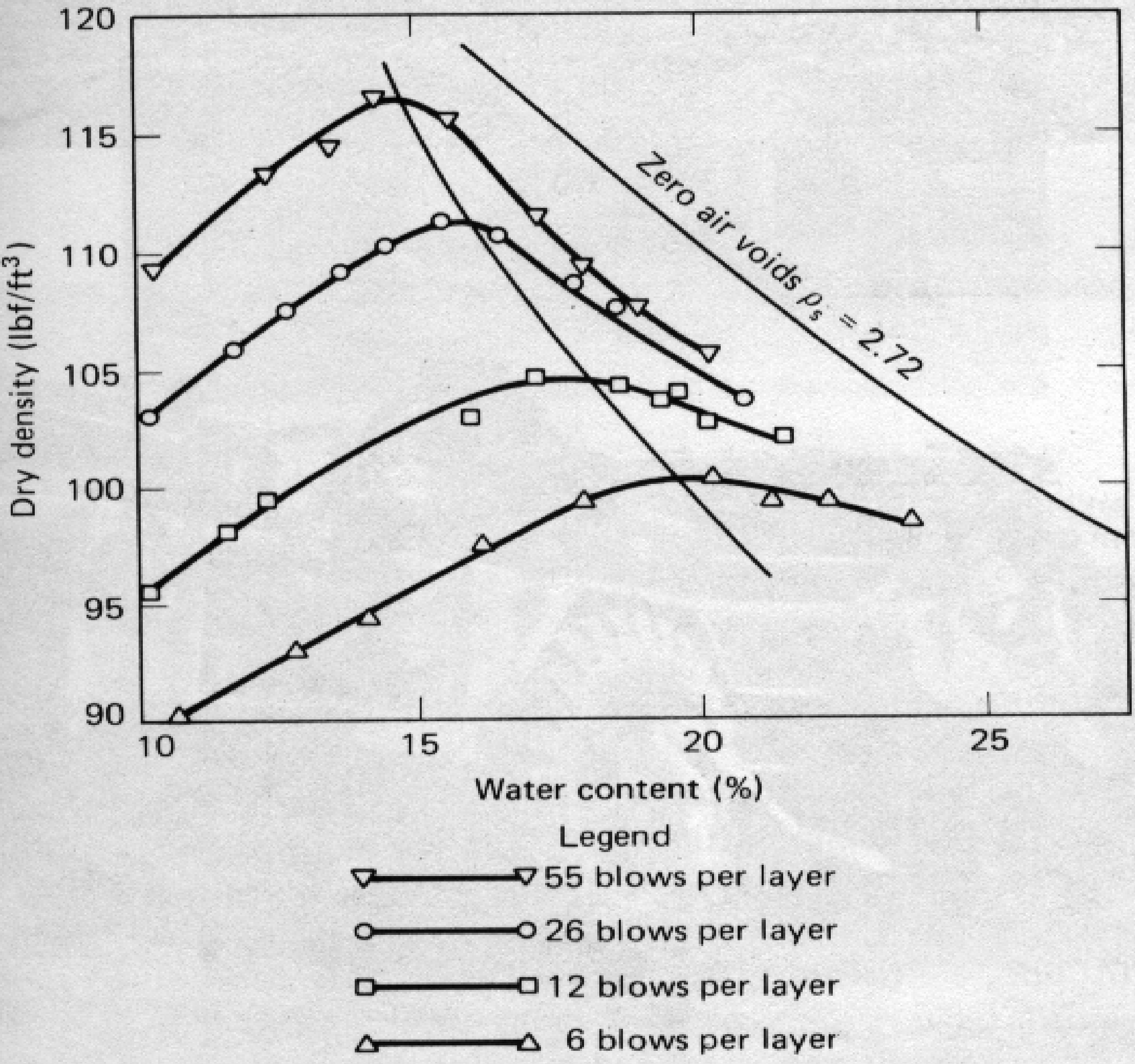


LOAD TEST ON — SUBGRADE
DIA. BEARING PLATE 0.76 m (30 IN.)
30,000
20,000
10,000
LOAD IN LB.
160
140
120
100
80
60
40
20
0
LOAD IN KN
0.0
0.1
0.2
0.3
0.4
0.5
0.6
SETTLEMENT IN INCHES

California bearing ratio (CBR)



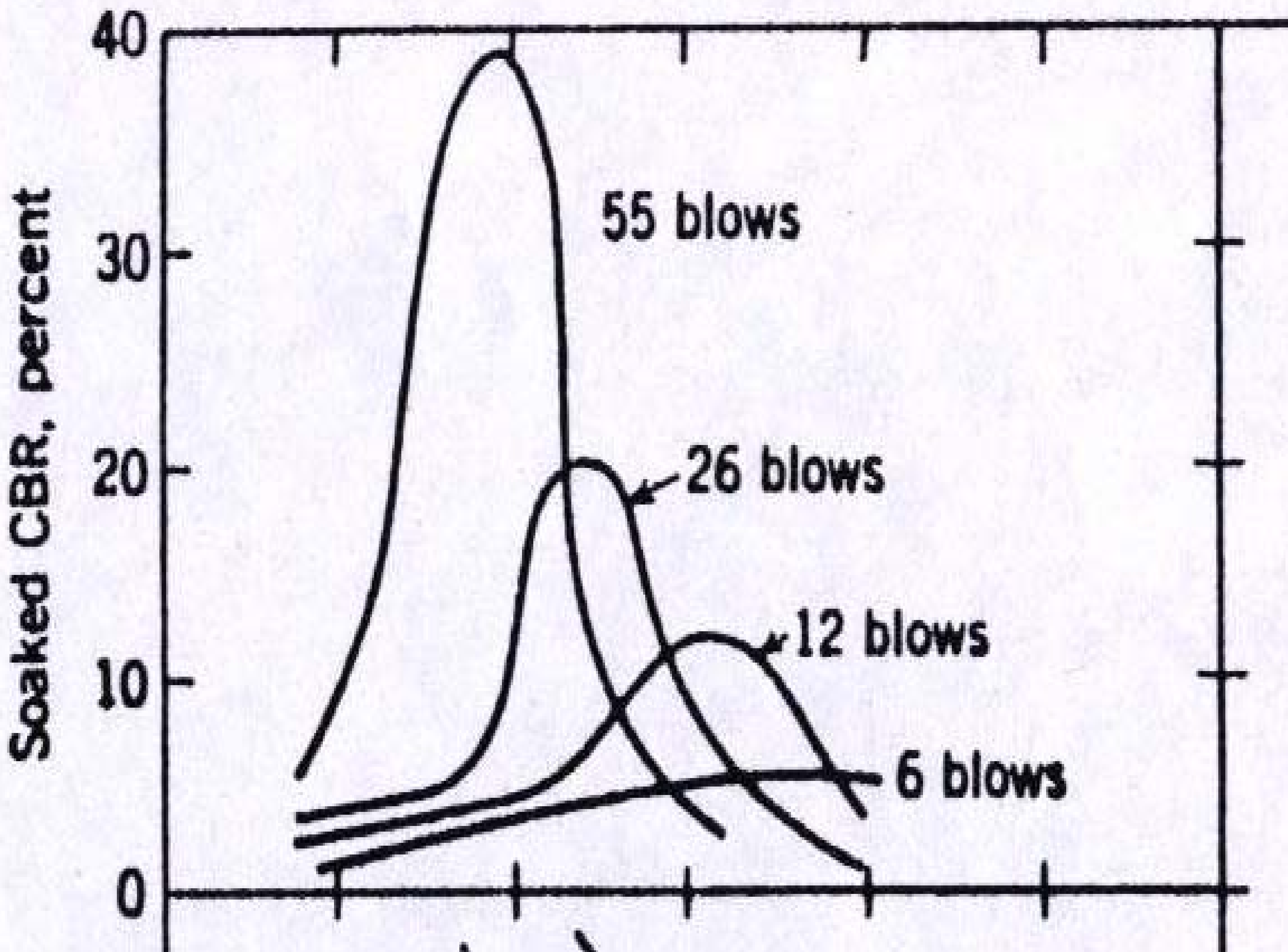

High compactive effort
E
B
D
C
A
Low compactive effort
Compacted dry density
Water content



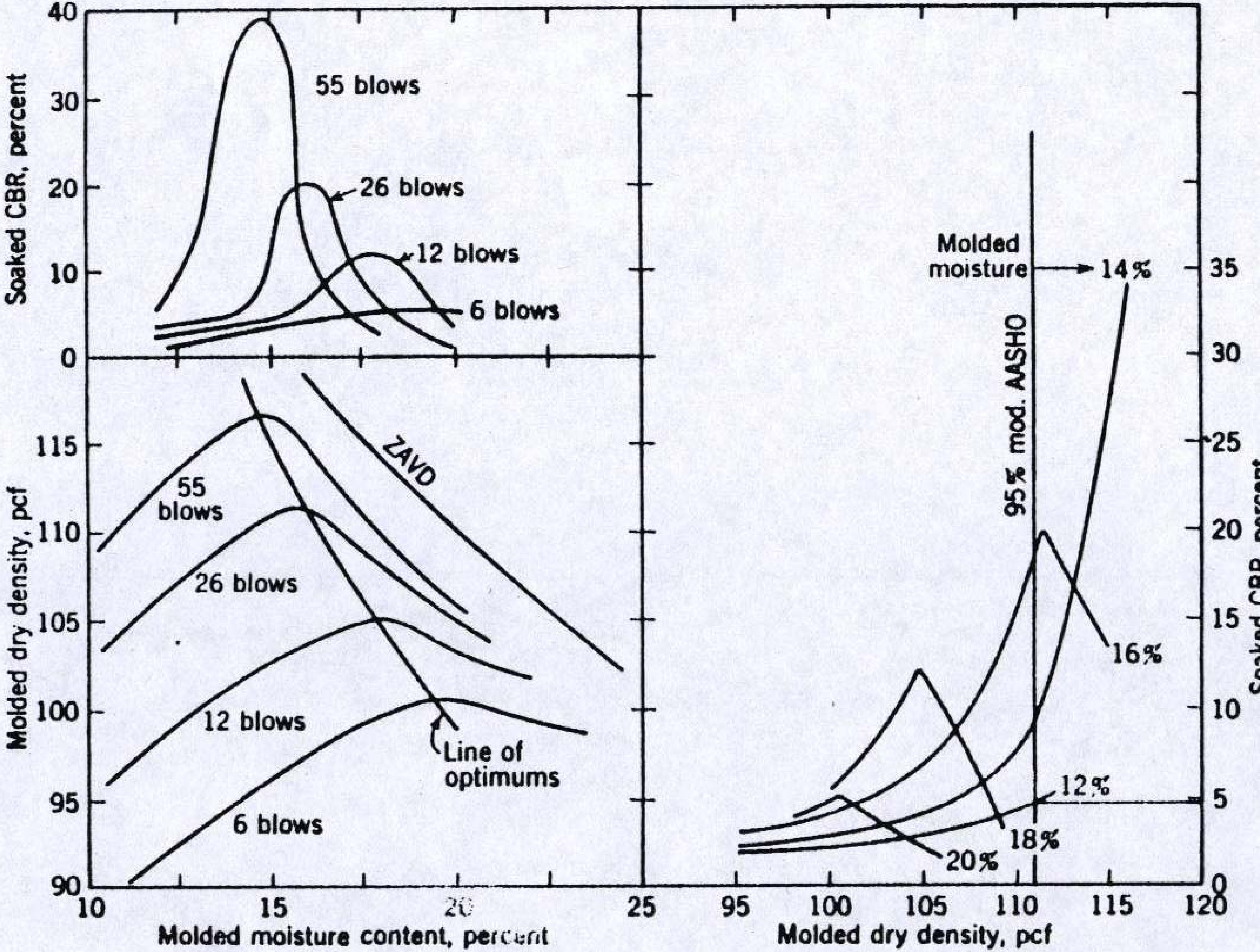
Note: 10 lb hammer, 18″ drop (modified Proctor)


4-Days

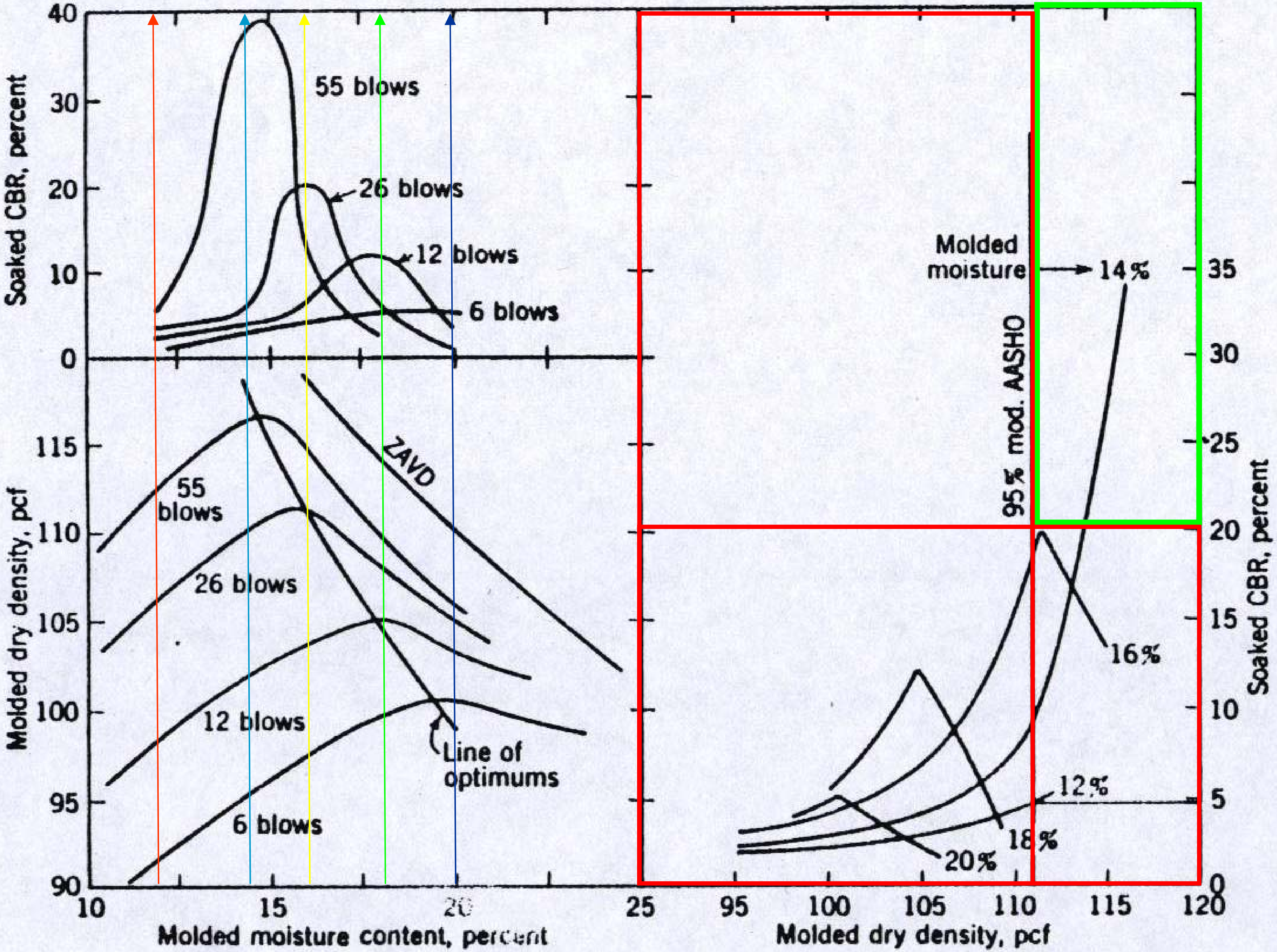
CRR= [{unit load at 0.1 or 0.2 penetration}/ {unit load at 0.1 or 0.2 penetration of standard material}] *100



40
30
20
10
0
Soaked CBR, percent
55 blows
26 blows
12 blows
6 blows



Soaked CBR, percent
55 blows
26 blows
12 blows
6 blows
Molded dry density, pcf
ZAVD
55 blows
26 blows
12 blows
6 blows
Line of optimums
Molded moisture content, percent
Molded moisture
14%
95% mod. AASHO
16%
12%
18%
20%
Molded dry density, pcf
Soaked CBR, percent



Soaked CBR, percent
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26 blows
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Molded dry density, pcf
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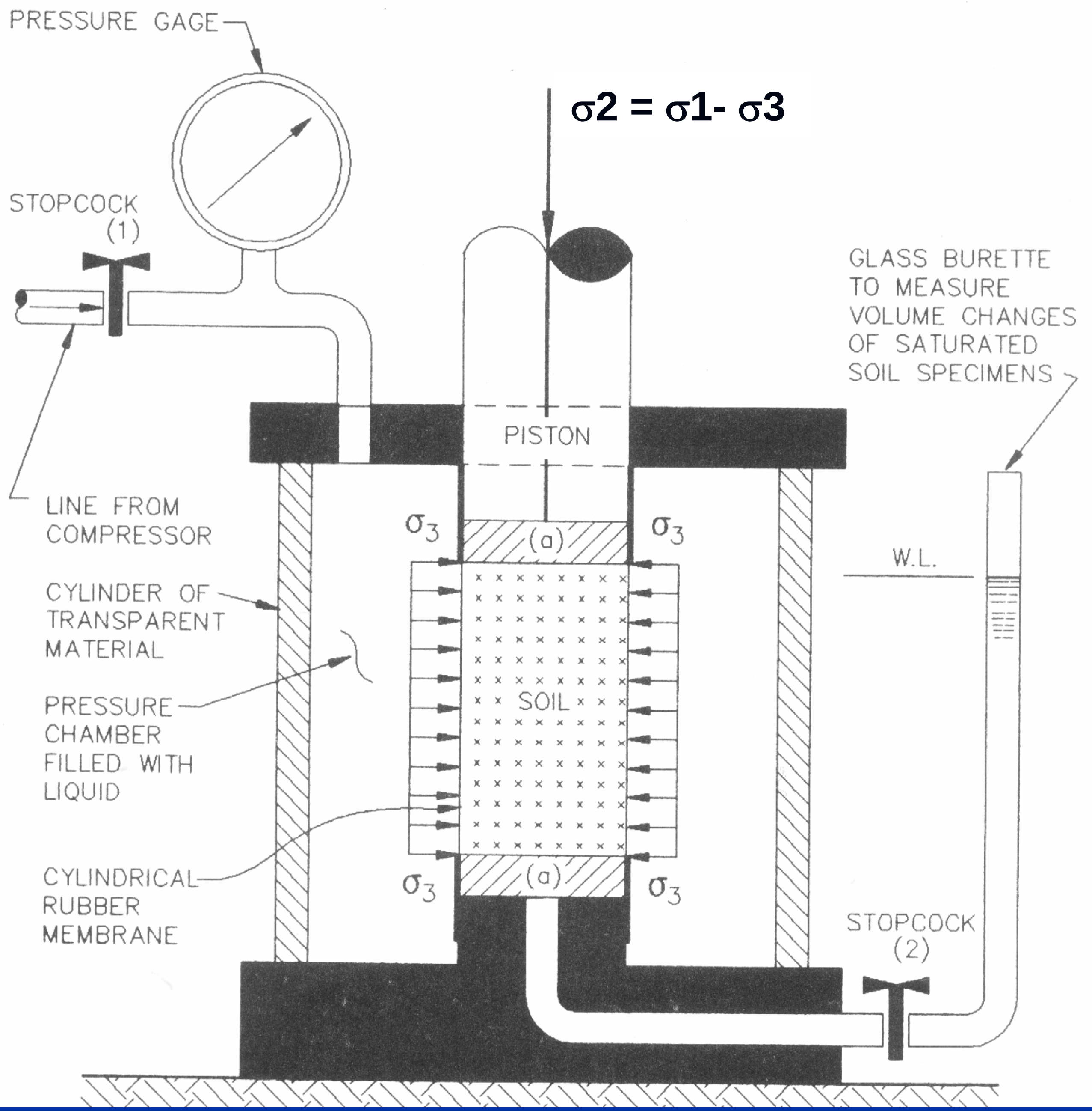
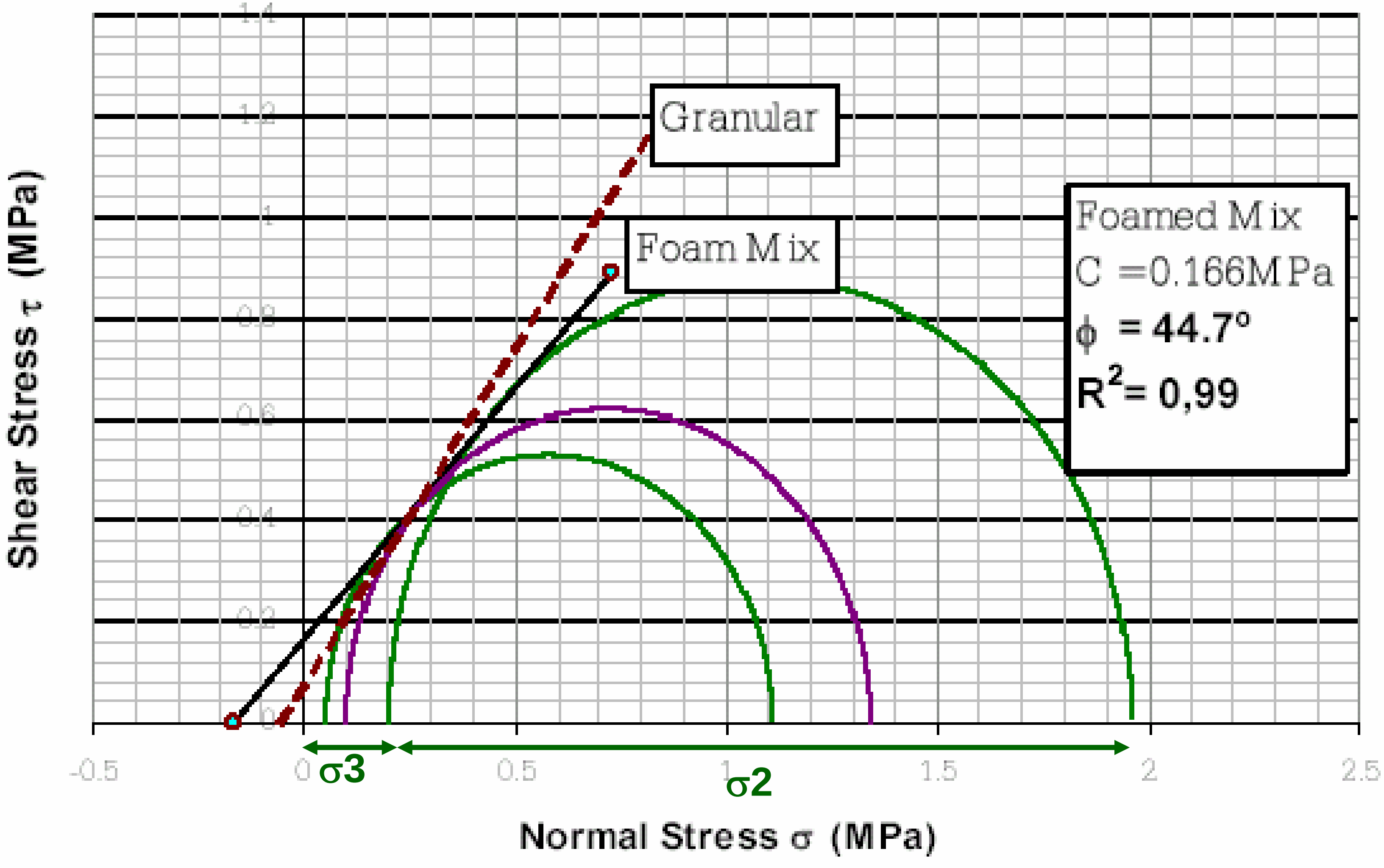
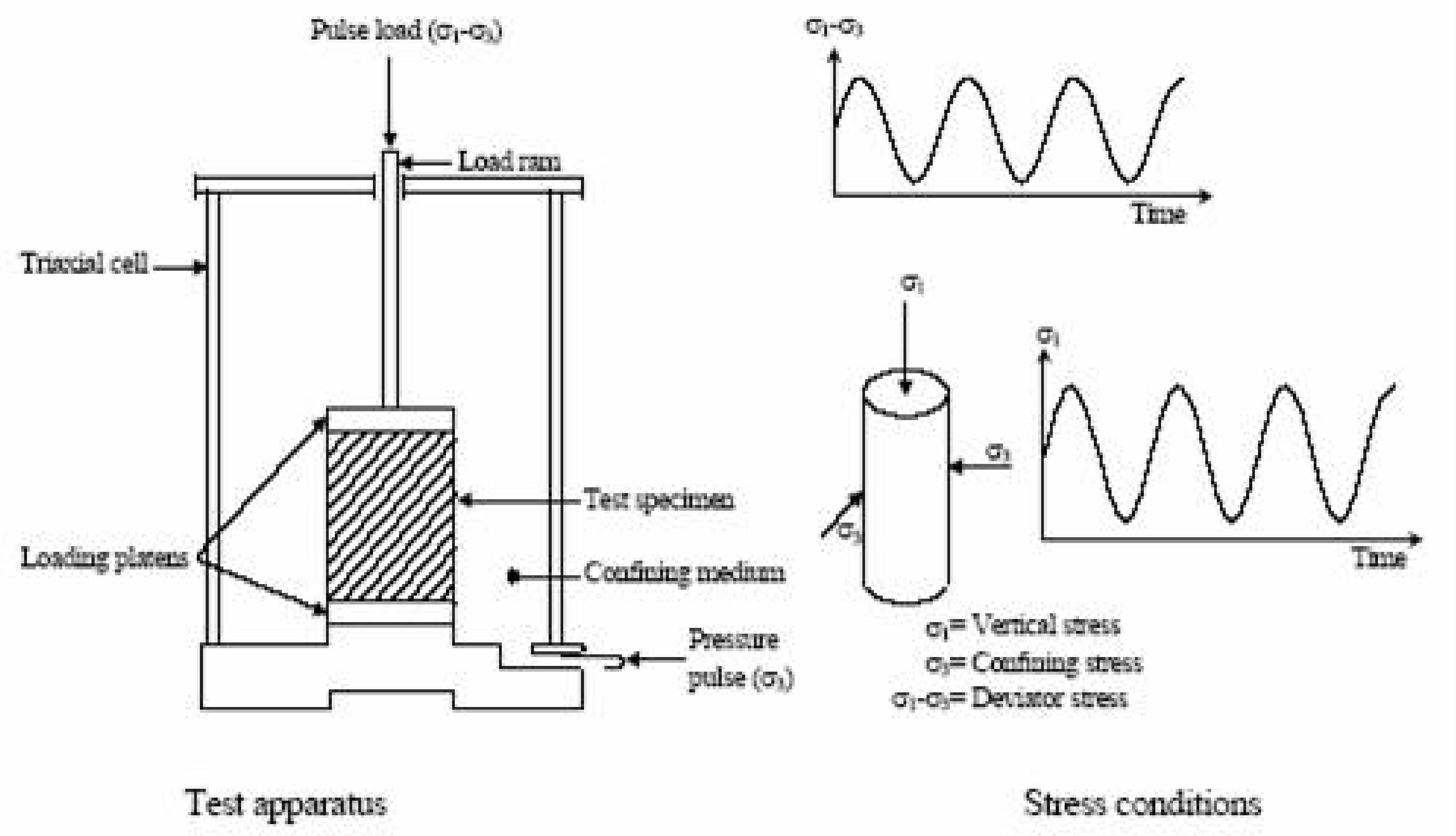
12%
18%
20%
Molded dry density, pcf
Soaked CBR, percent



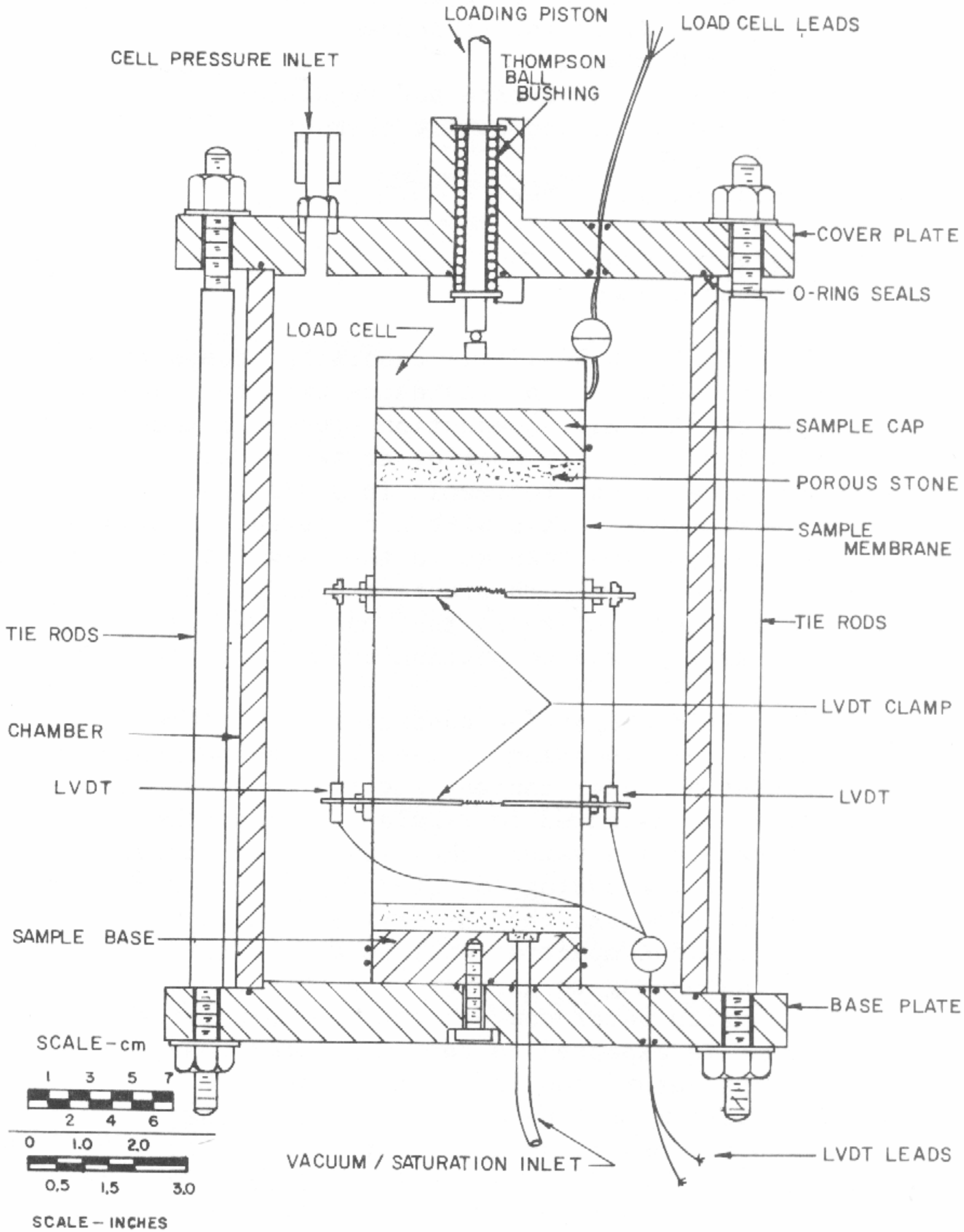
Static triaxial test (ϕ, angle of internal friction, C, cohesion and τ, shear)

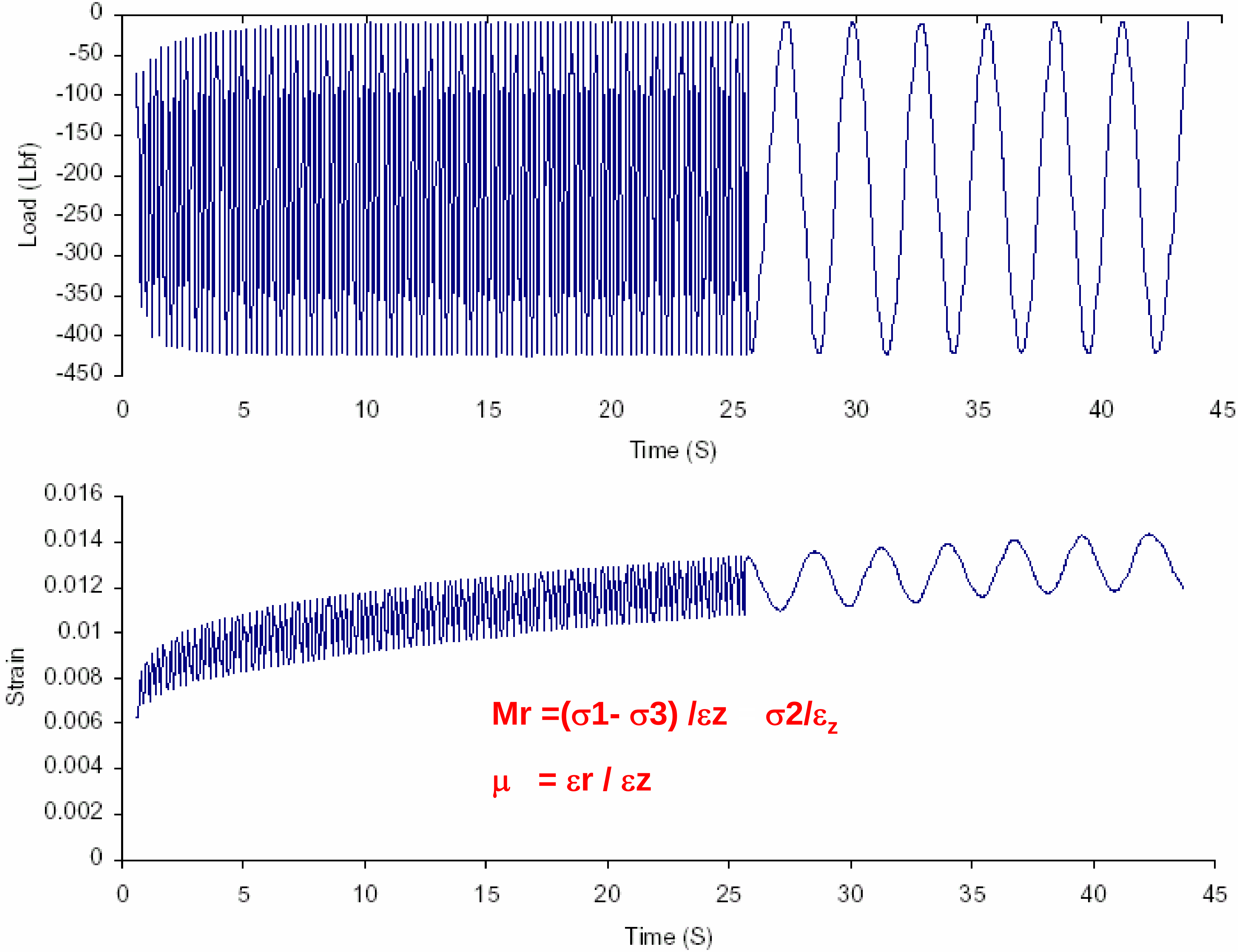
$$\tau = c + \sigma \tan \phi$$





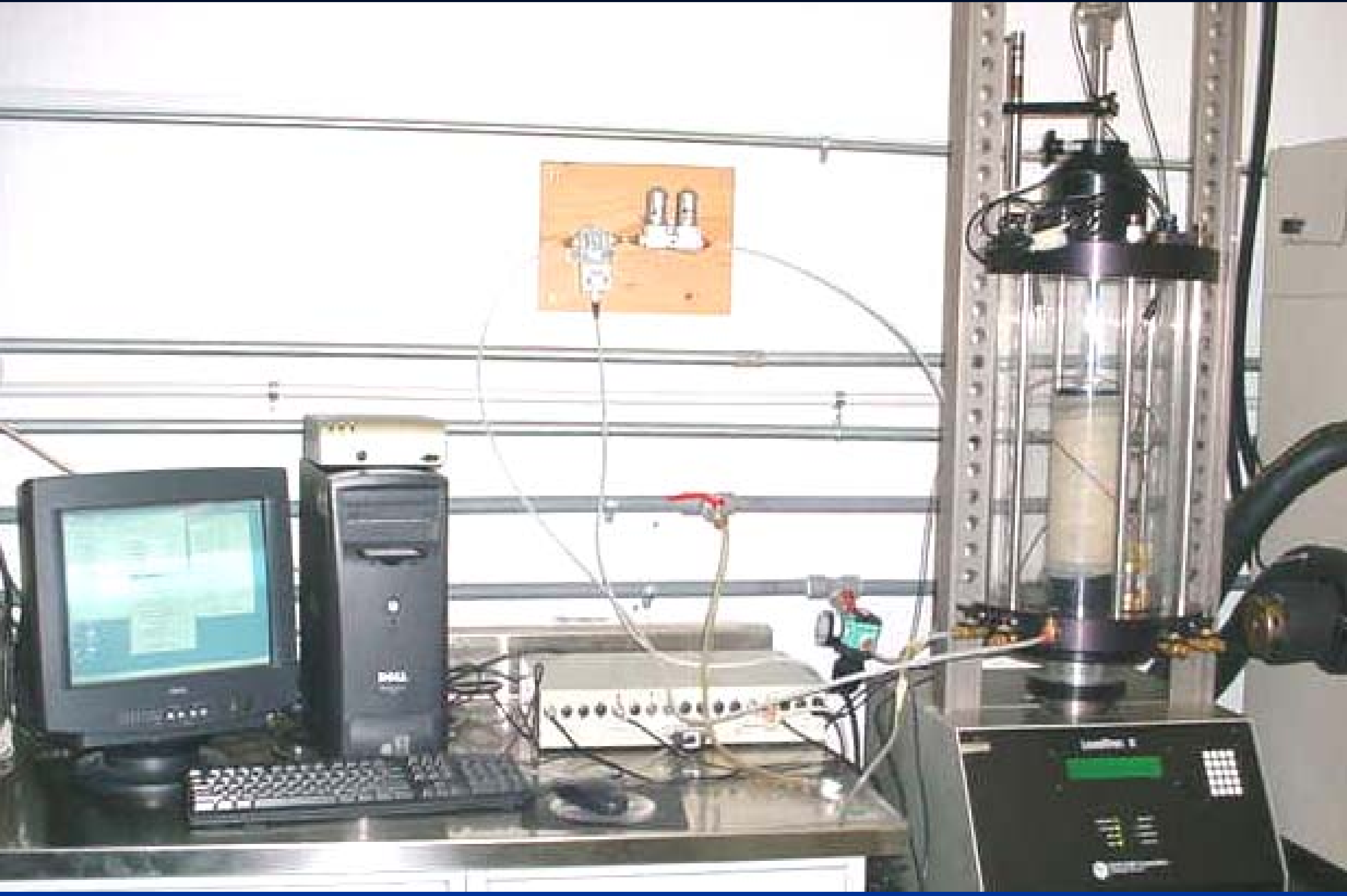
➢**Dynamic triaxial test** (permanent deformation, resilient modulus (Mr) for **fine** and **coarse** materials and poisons ratio (μ))

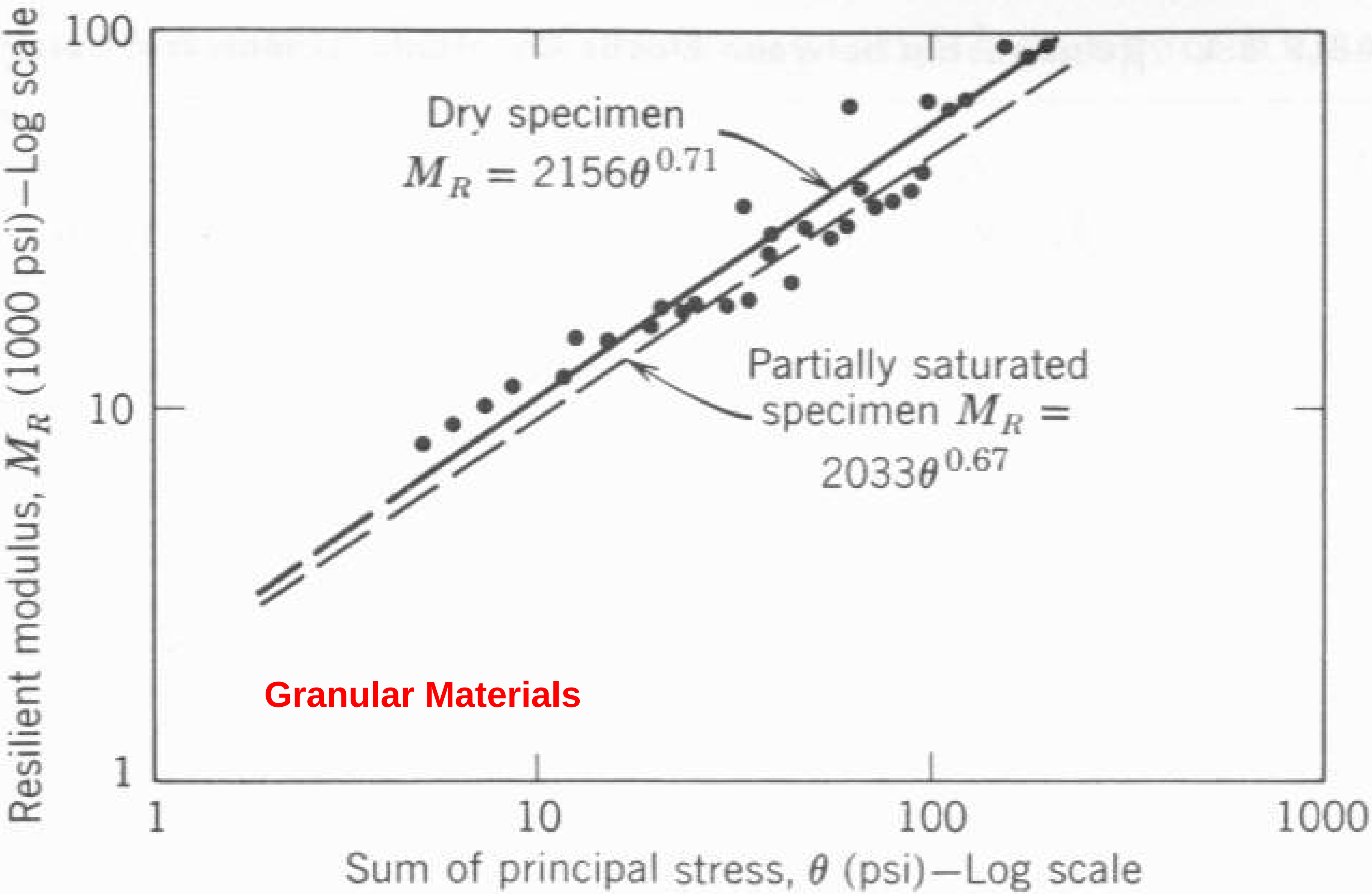

LOADING PISTON
LOAD CELL LEADS
CELL PRESSURE INLET
THOMPSON BALL BUSHING
COVER PLATE
O-RING SEALS
LOAD CELL
SAMPLE CAP
POROUS STONE
SAMPLE MEMBRANE
TIE RODS
TIE RODS
LVDT CLAMP
CHAMBER
LVDT
LVDT
SAMPLE BASE
BASE PLATE
SCALE-cm
1 3 5 7
2 4 6
0 1.0 2.0
0.5 1.5 3.0
SCALE - INCHES
VACUUM / SATURATION INLET
LVDT LEADS



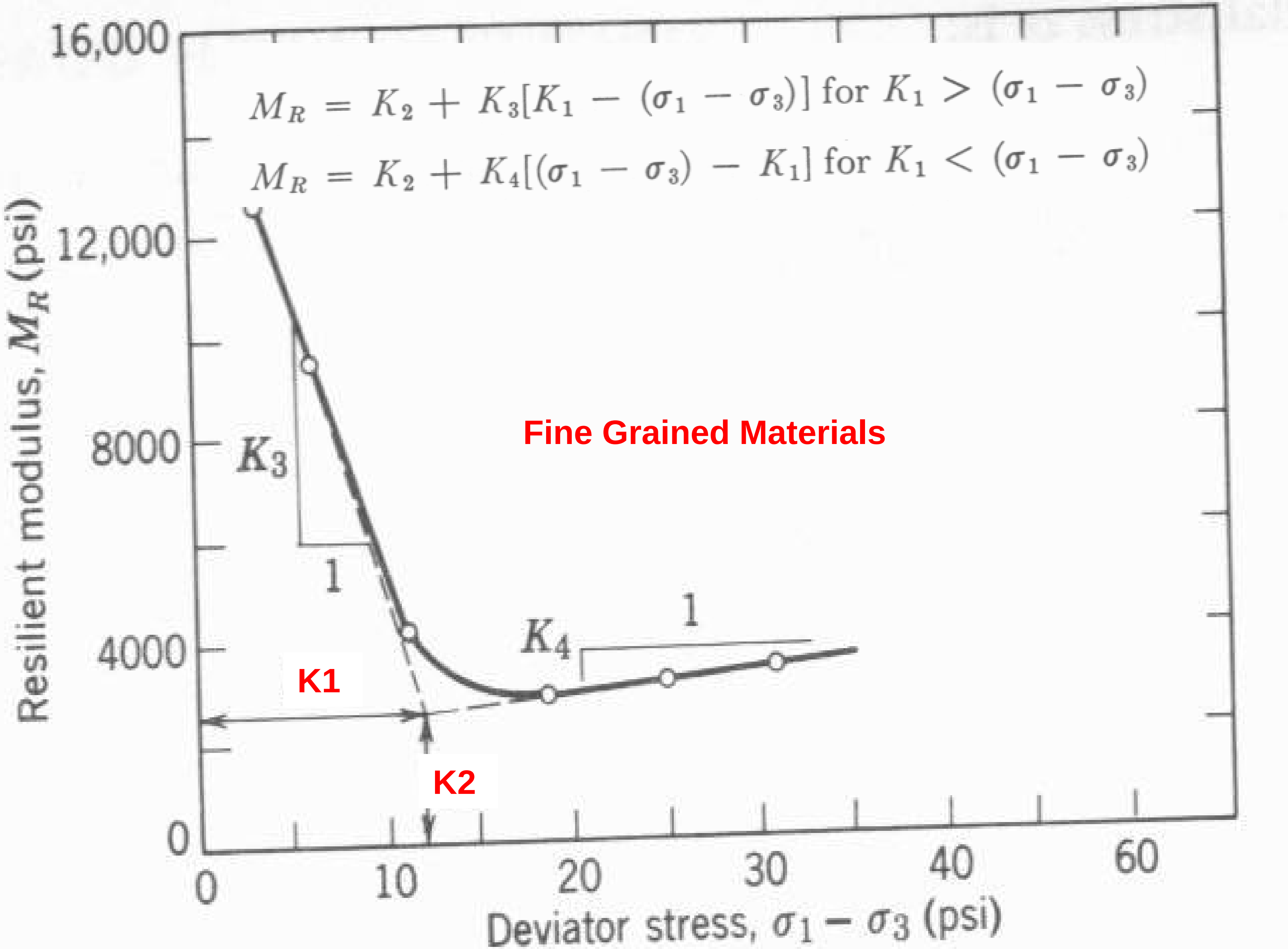
$M_r = (\sigma 1 - \sigma 3) / \varepsilon z \quad \sigma 2 / \varepsilon_z$

$\mu = \varepsilon r / \varepsilon z$



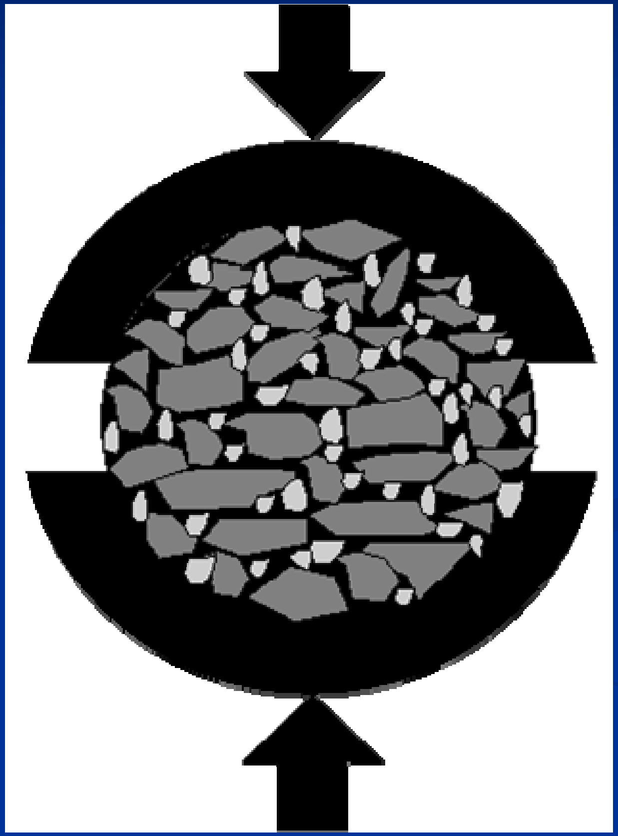


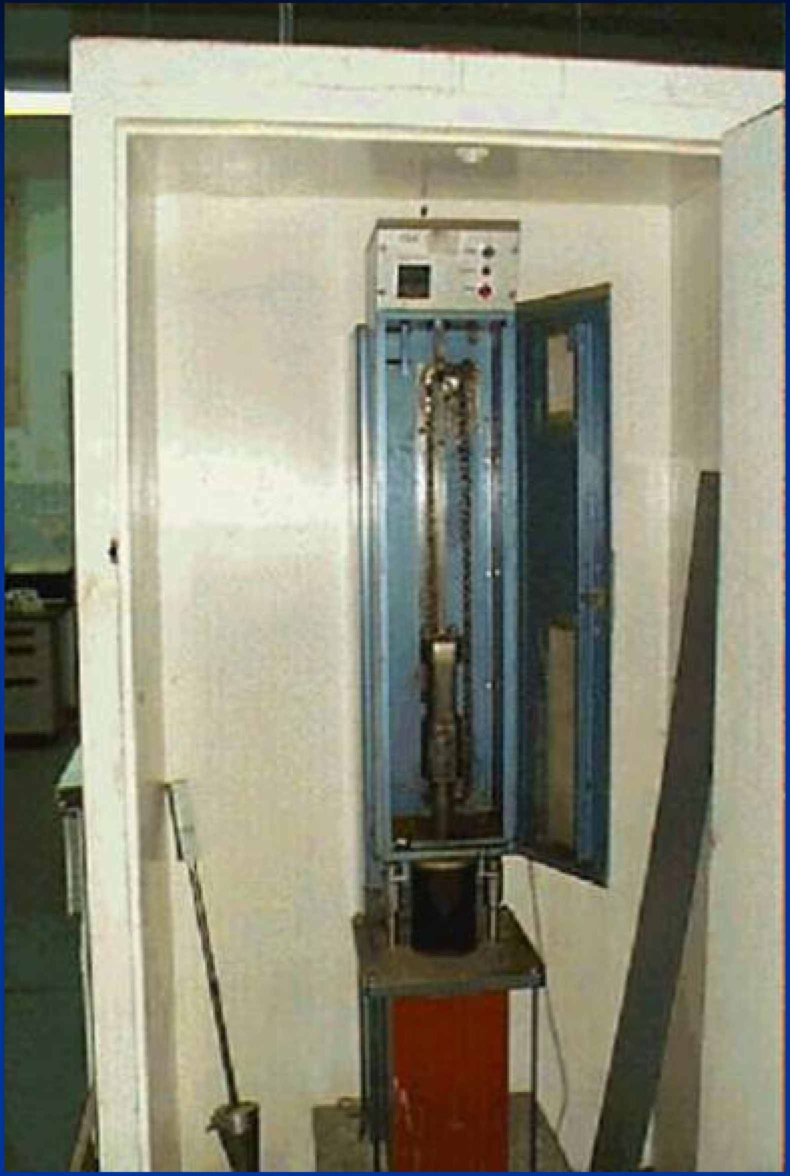
re 8.12. Typical M_R response for granular materials. (From Hi

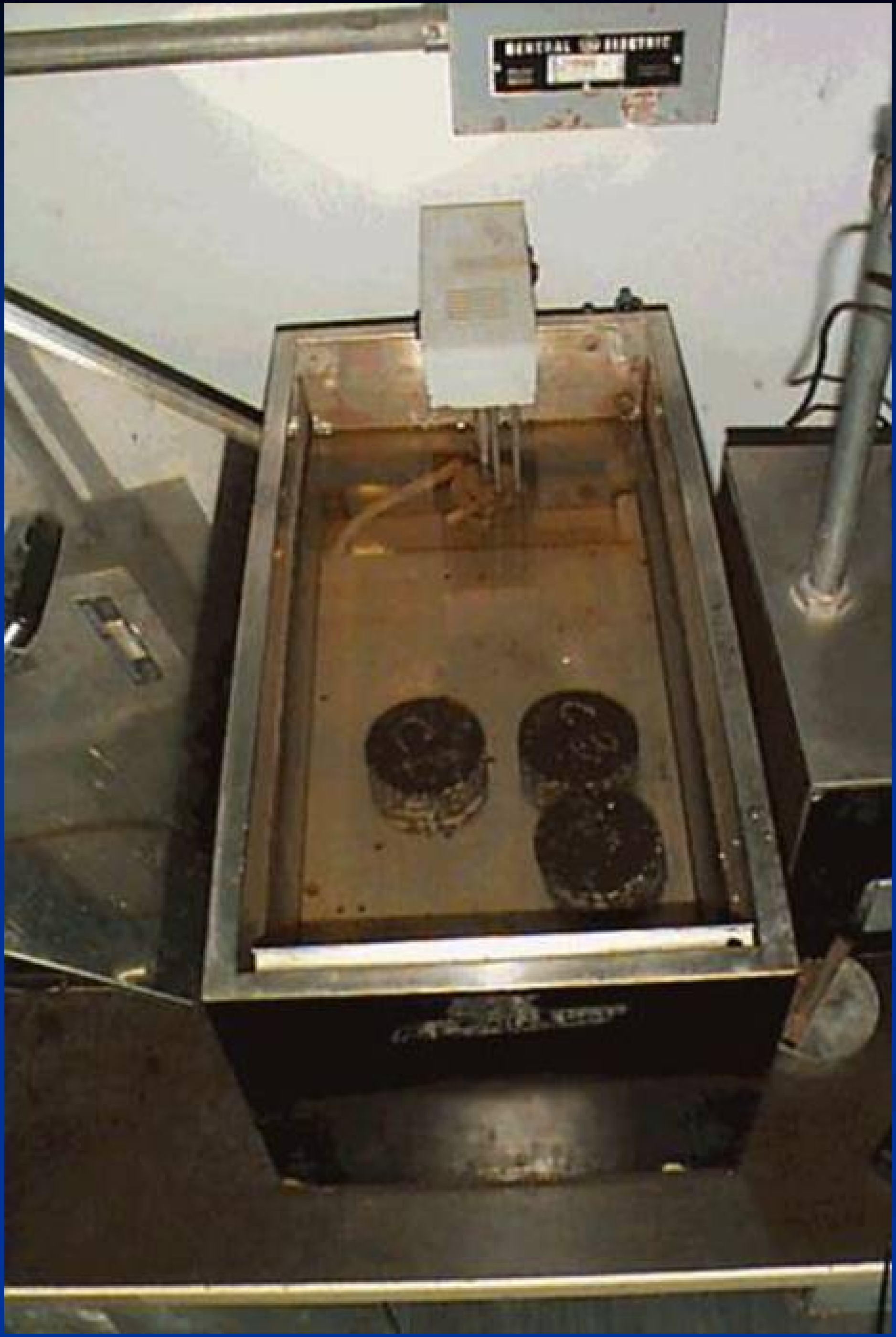


$M_R = K_2 + K_3[K_1 - (\sigma_1 - \sigma_3)]$ for $K_1 > (\sigma_1 - \sigma_3)$
$M_R = K_2 + K_4[(\sigma_1 - \sigma_3) - K_1]$ for $K_1 < (\sigma_1 - \sigma_3)$
Fine Grained Materials
16,000
12,000
8000
4000
0
K_3
1
K_4
1
K1
K2
0
10
20
30
40
60
Resilient modulus, M_R (psi)
Deviator stress, $\sigma_1 - \sigma_3$ (psi)

- Marshall test



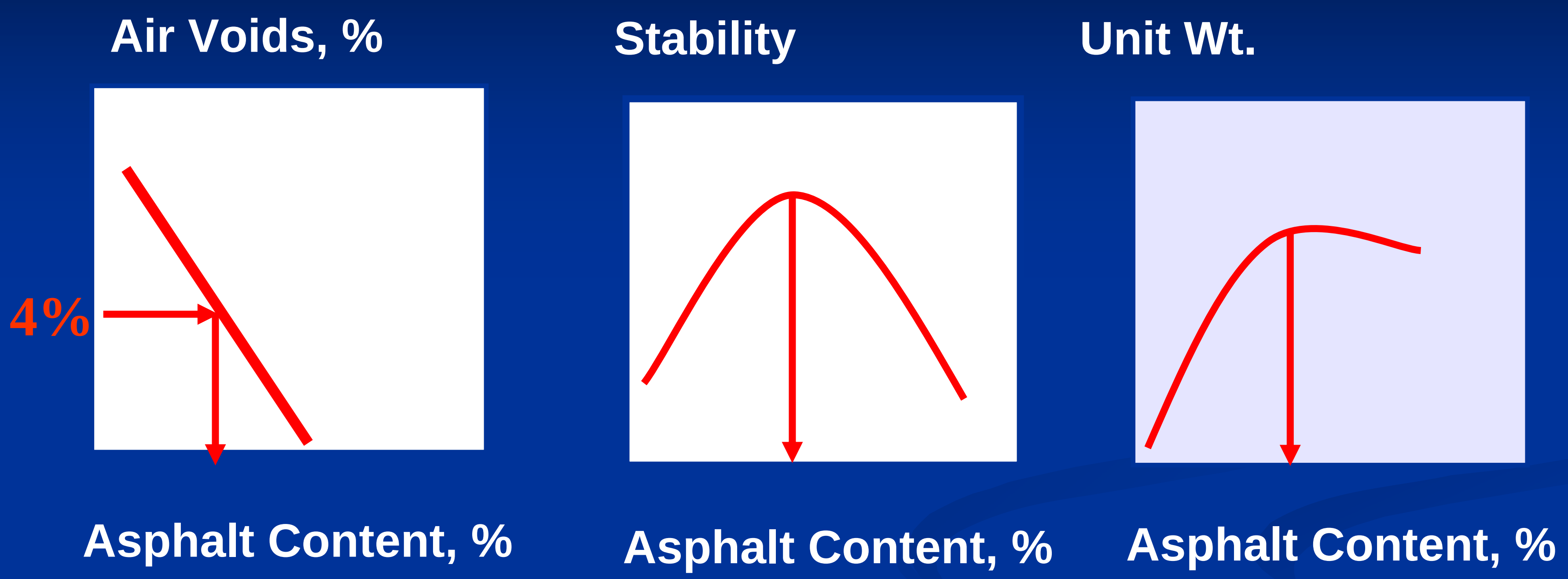





ELT


PINE
INSTRUMENT

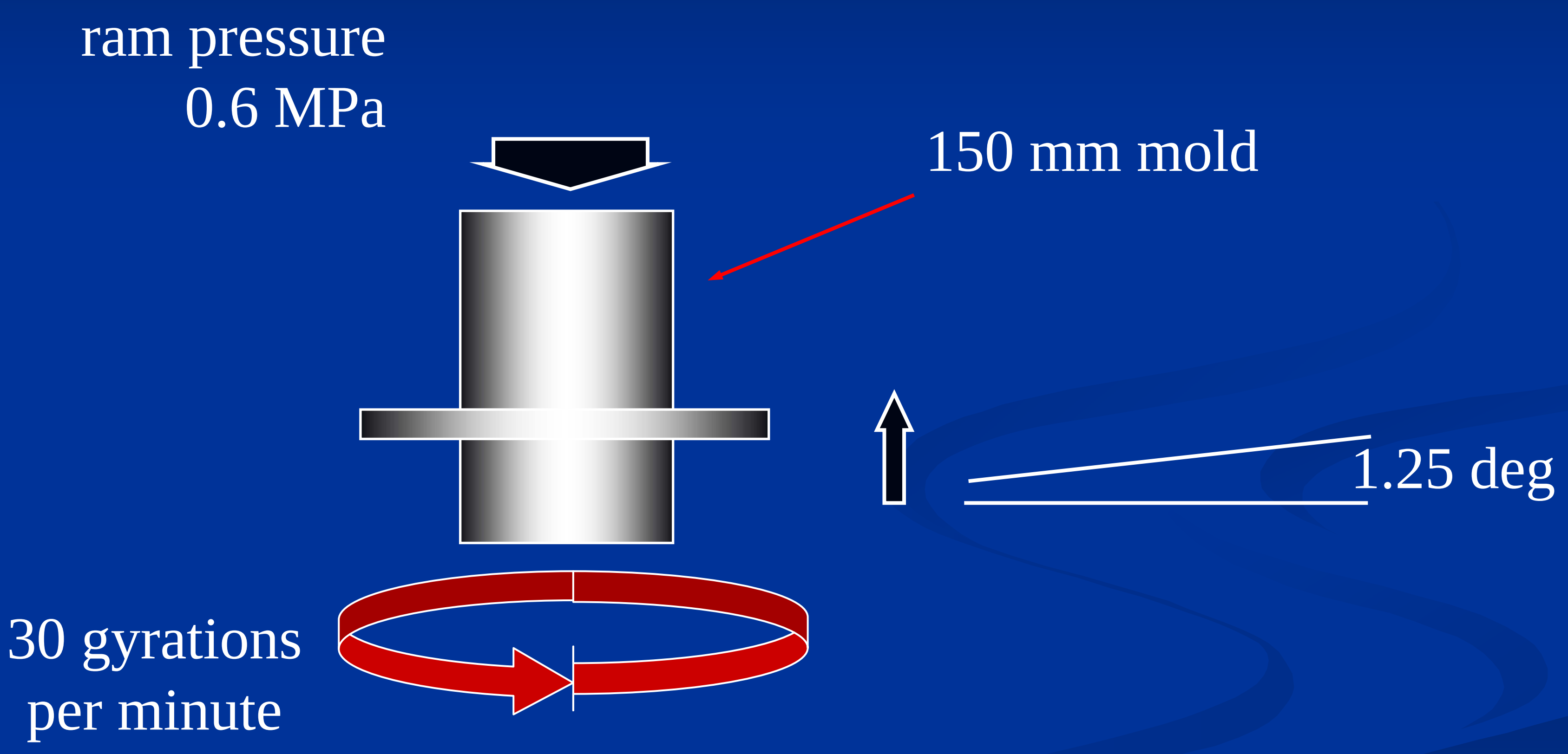
Marshall Design Use of Data
Asphalt Institute Procedure



Target optimum asphalt content = average


SuperPave
TROXLER
CAUTION
KEEP HANDS
OUT OF MOVING
MACHINERY

Gyratory Compaction



$$\sigma = \frac{3aP}{bh^2} \quad ($$

❑Modulus of rupture, MR, Es

$$E_s = \frac{Pa(3L^2 - 4a^2)}{4bh^3\Delta} \quad (7$$

$$\epsilon_t = \frac{\sigma}{E_s} = \frac{12h\Delta}{3L^2 - 4a^2} \quad (7$$

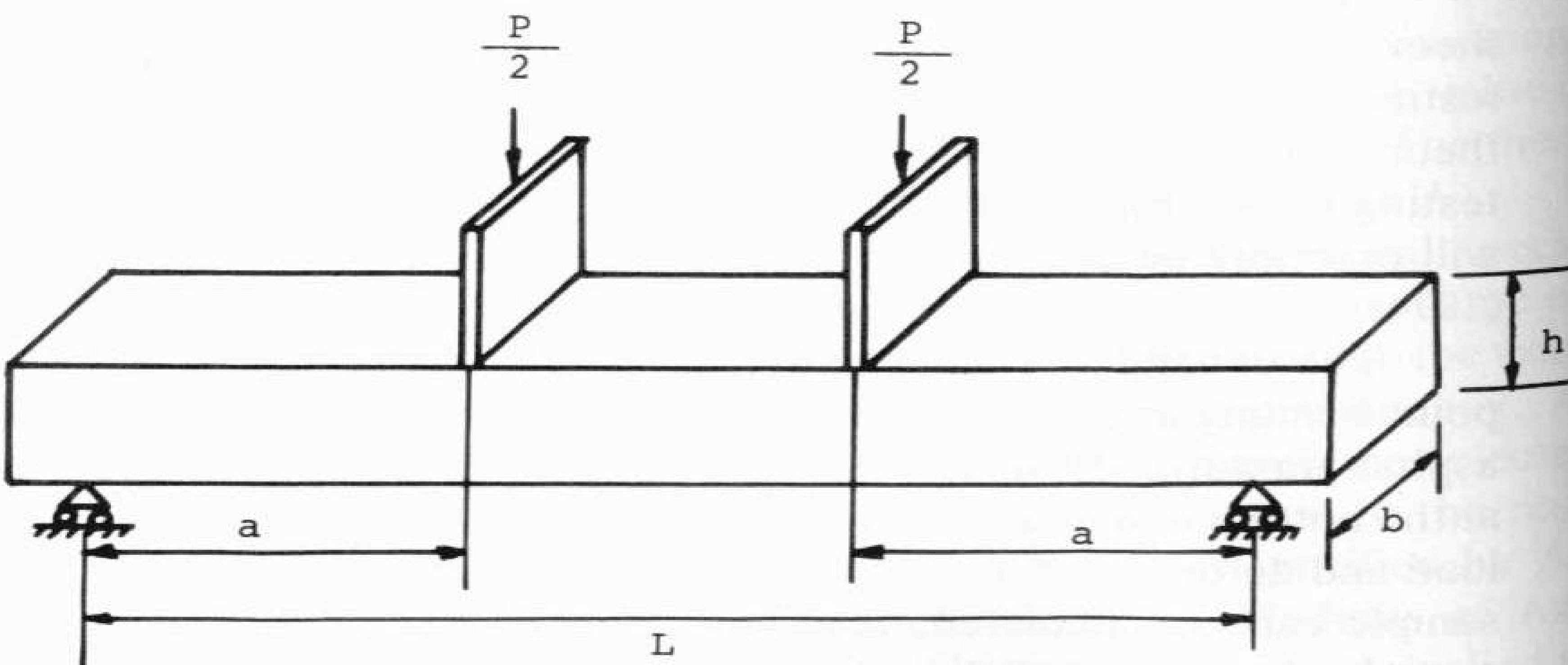
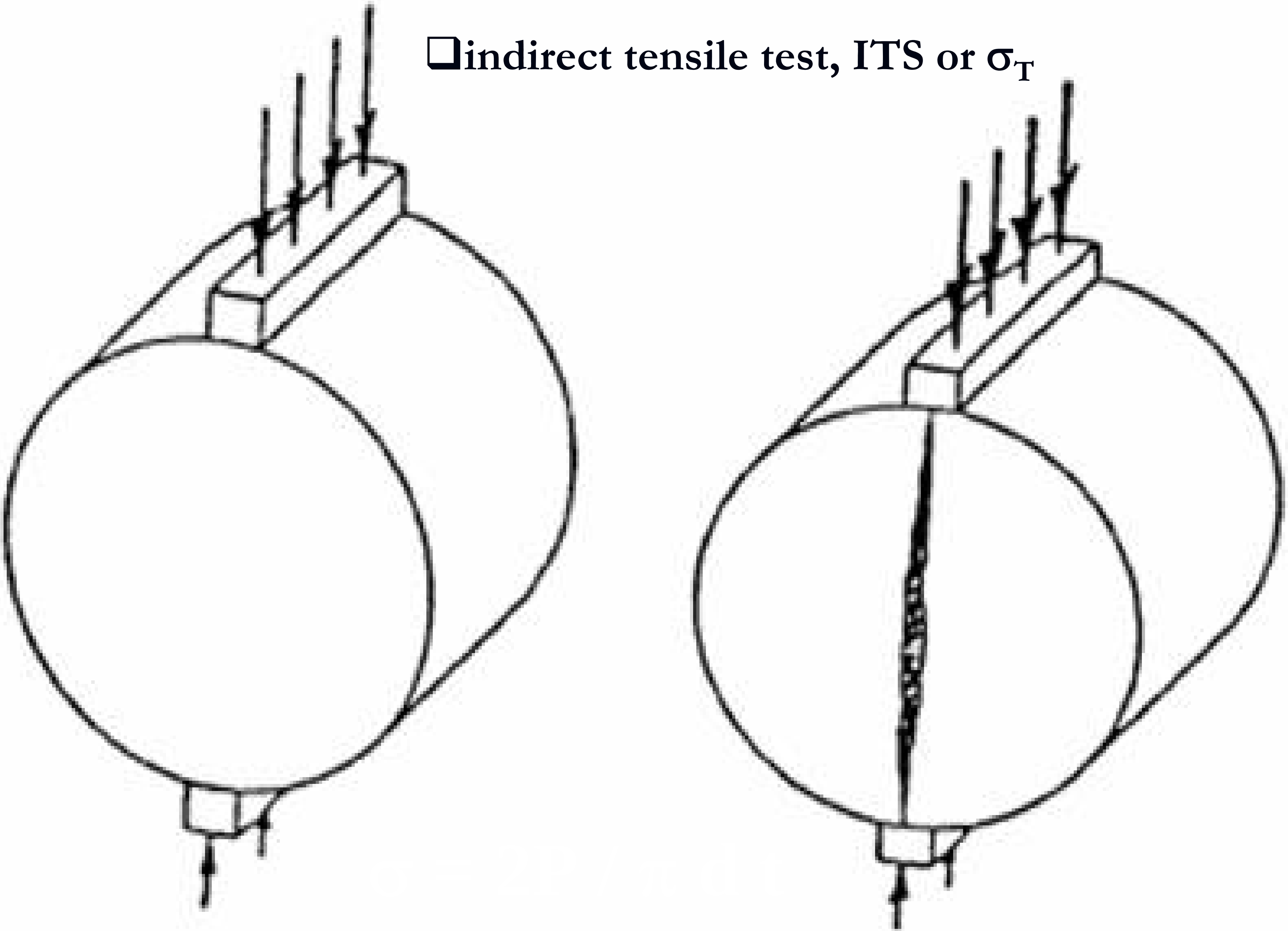
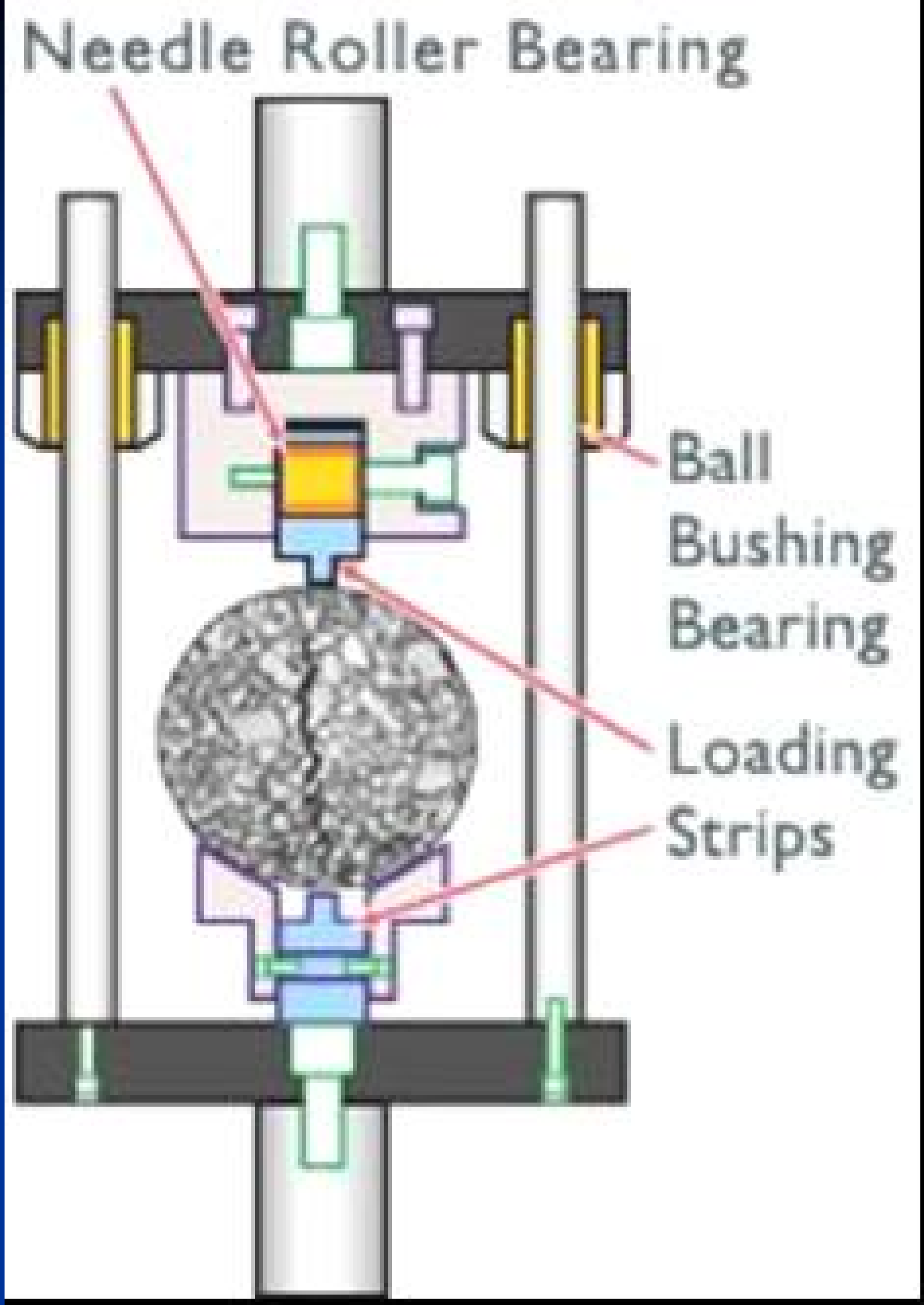


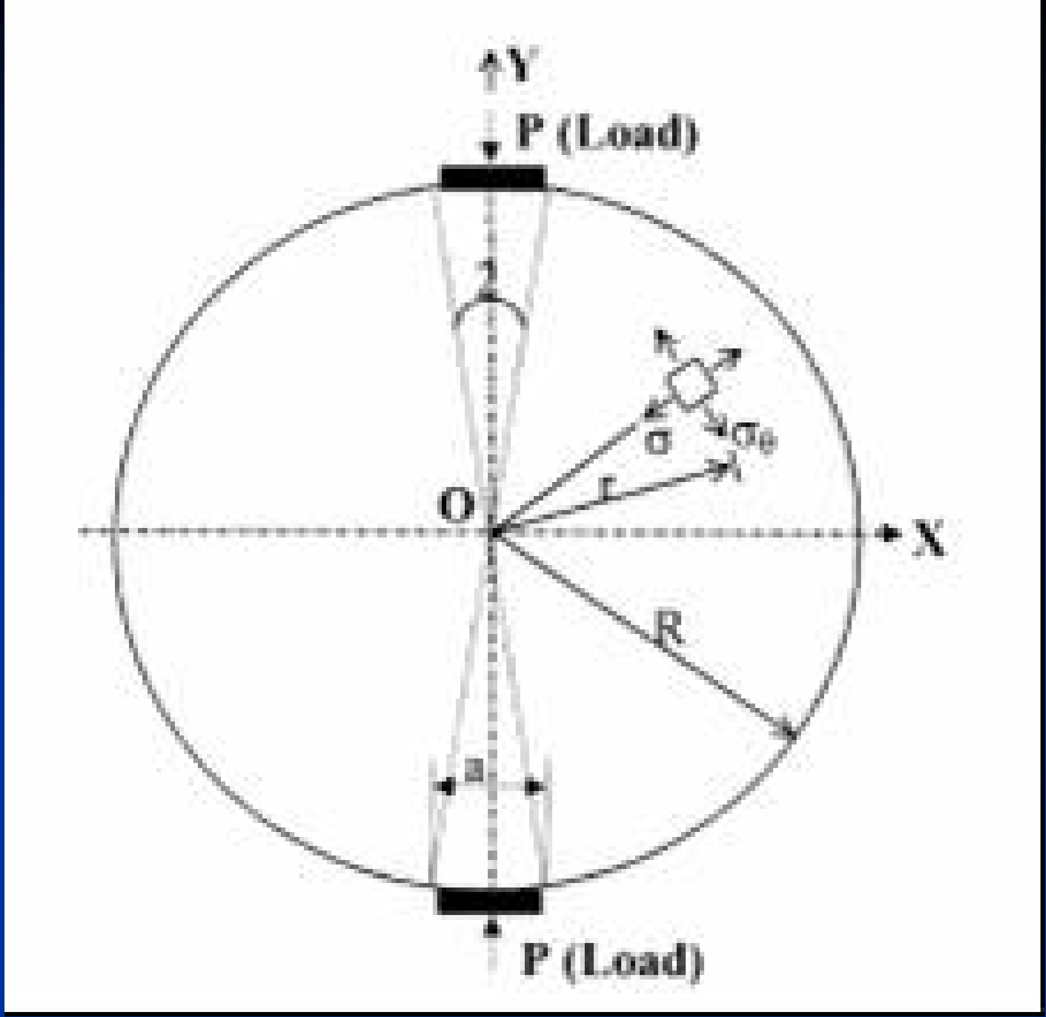
Figure 7.17 Third-point beam test for dynamic modulus.

❑indirect tensile test, ITS or σ_T



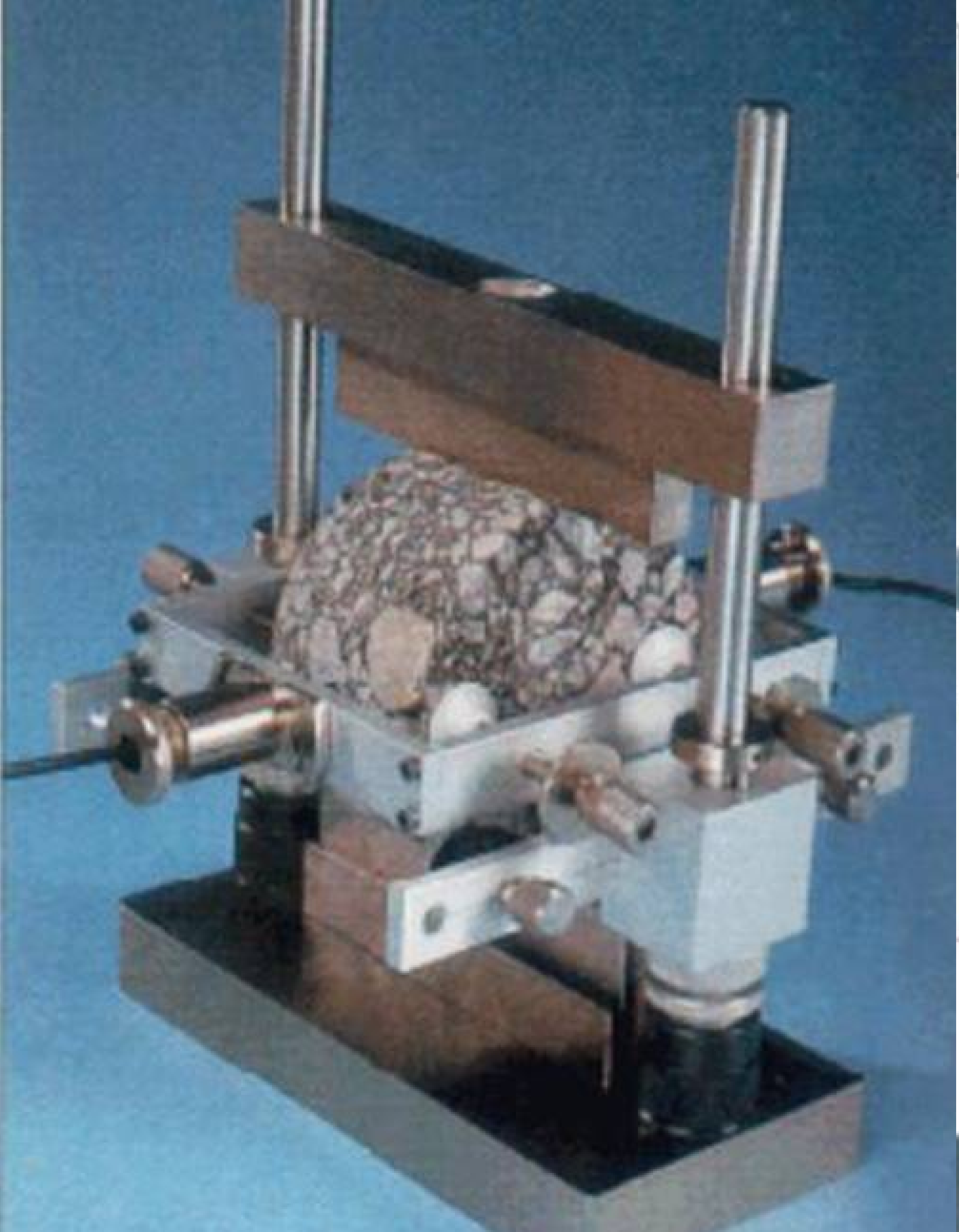

Needle Roller Bearing
Ball
Bushing
Bearing
Loading
Strips

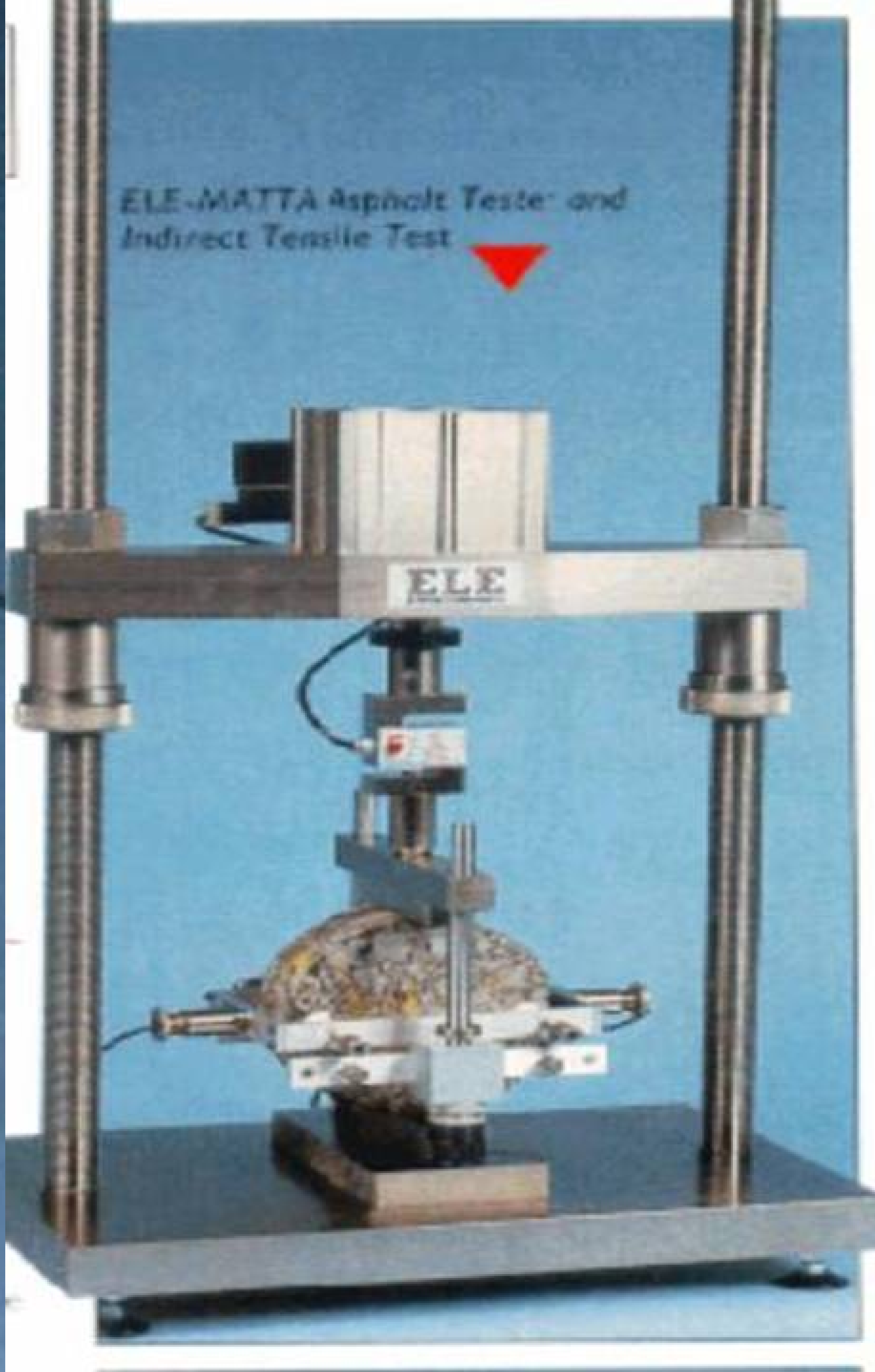
$$\sigma_T = 2P/\mu\ D\ H$$



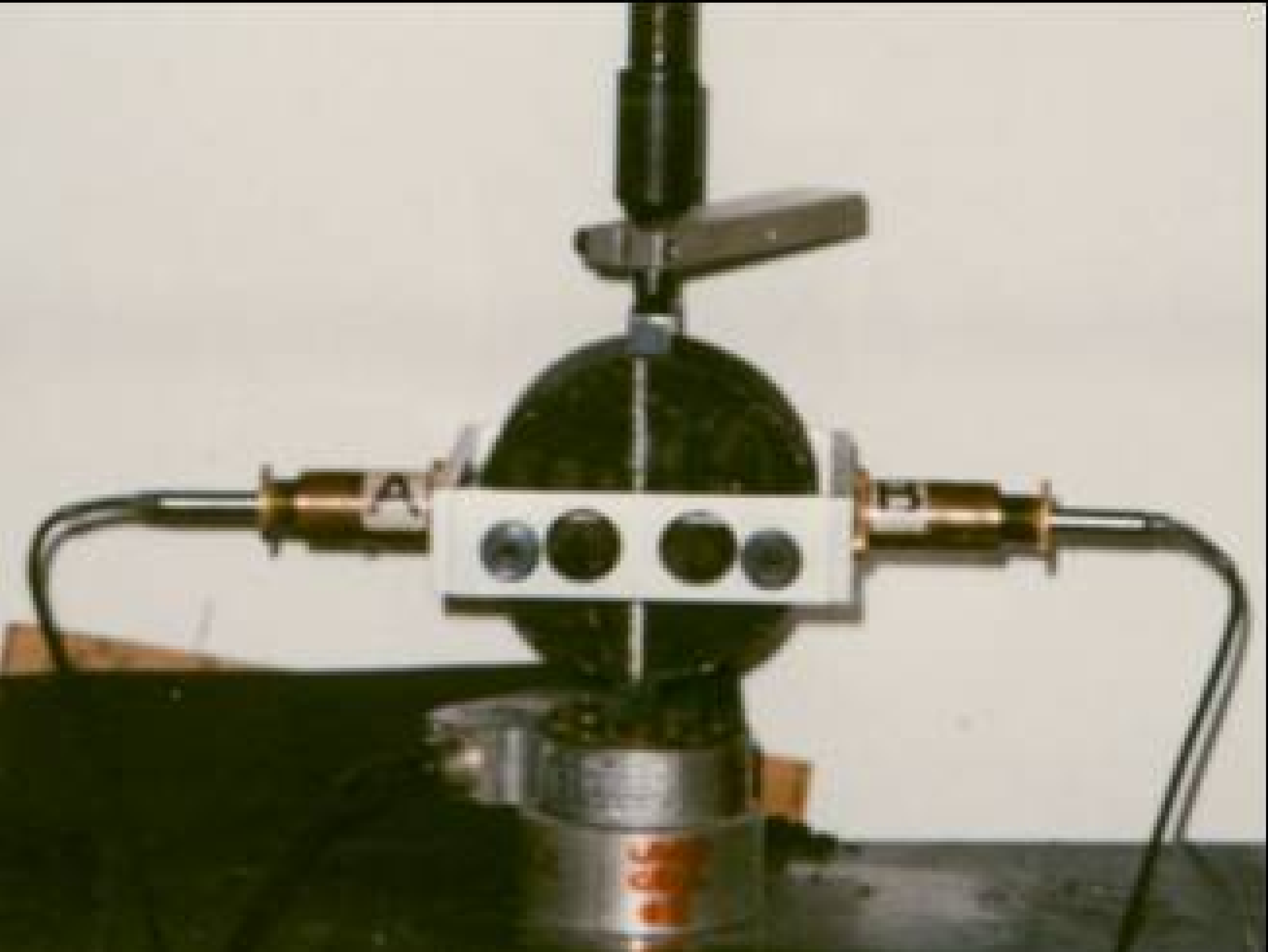
$$\text{Horizontal Tensile Stress} = \sigma = \frac{2P}{\pi d t}$$

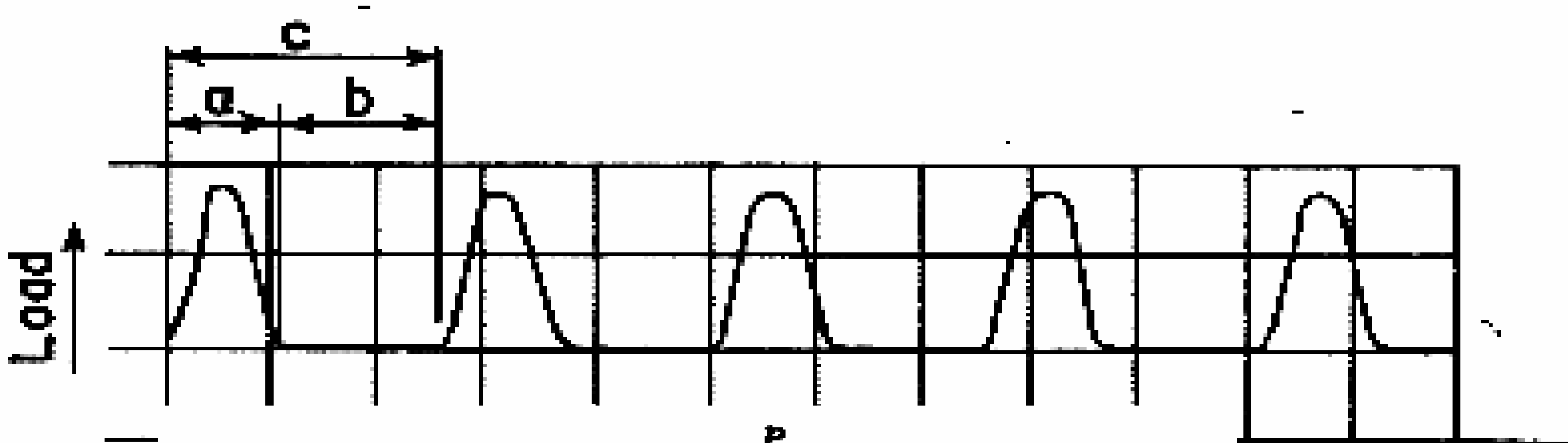
$$\text{Horizontal Tensile Strain} = \varepsilon = \delta\left[\frac{2(1+3\mu)}{d\,(a+b\mu)\,\pi}\right]$$





❑Diametral test, resilient modulus,Mr

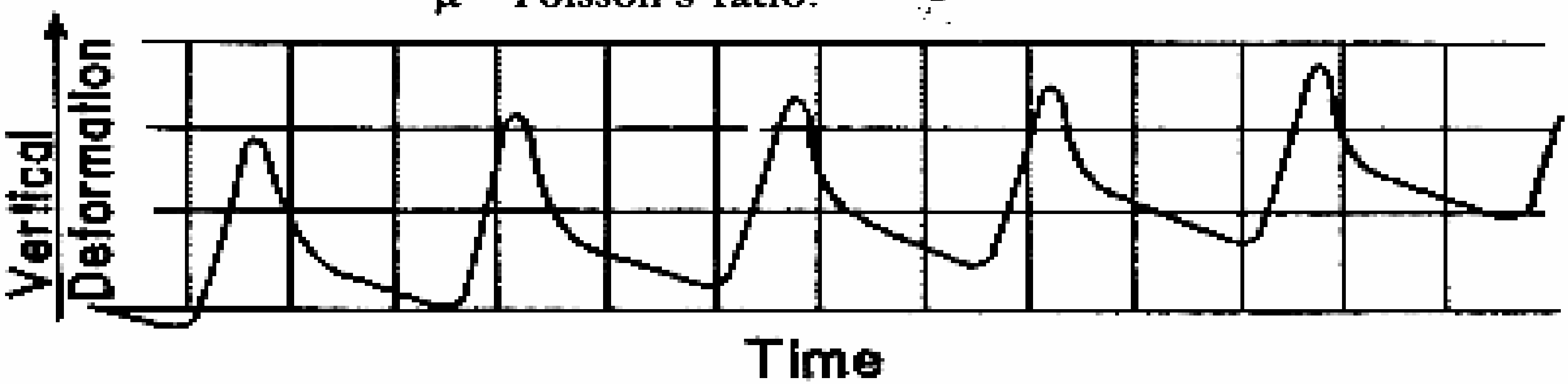

A
H

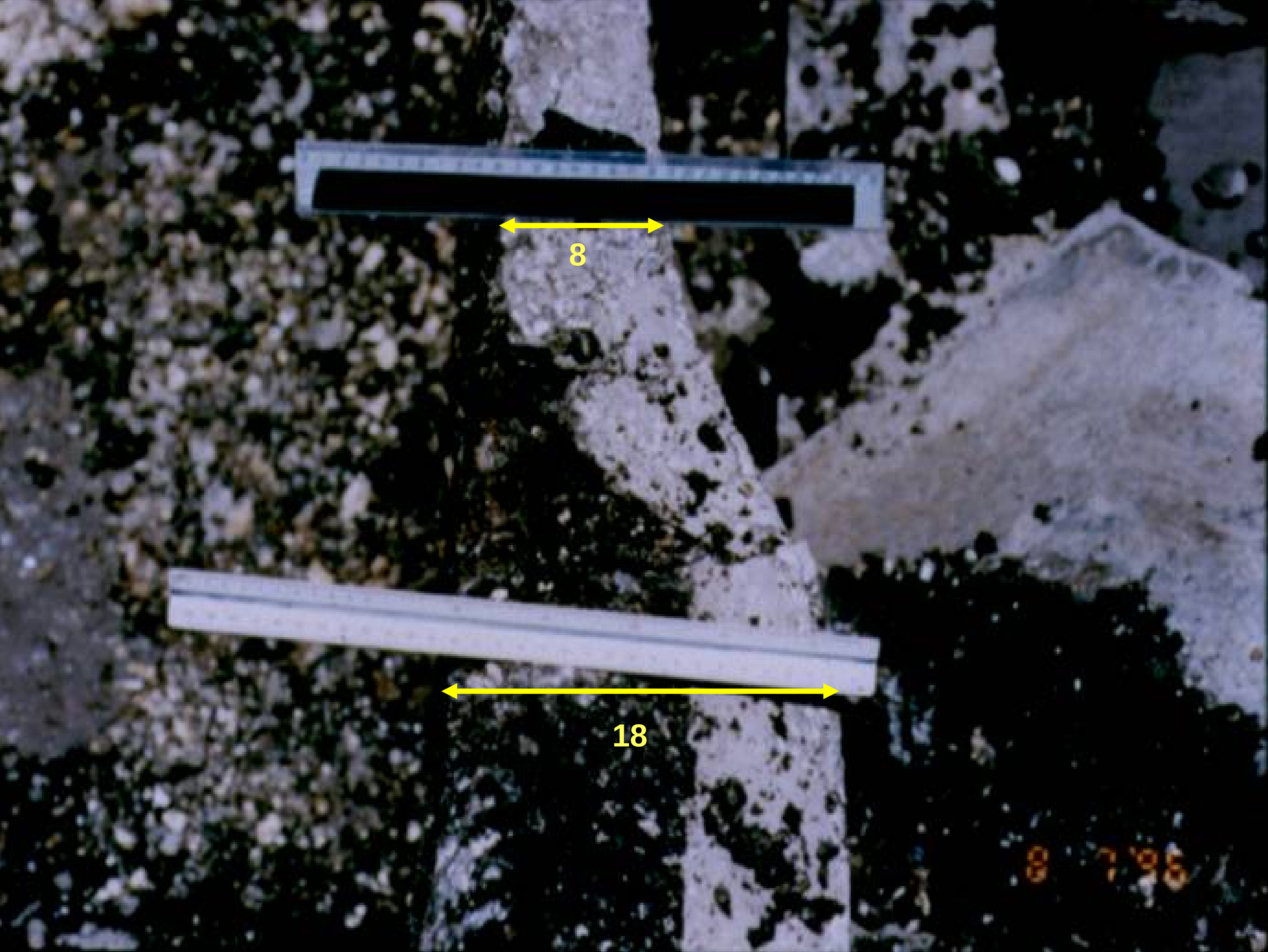


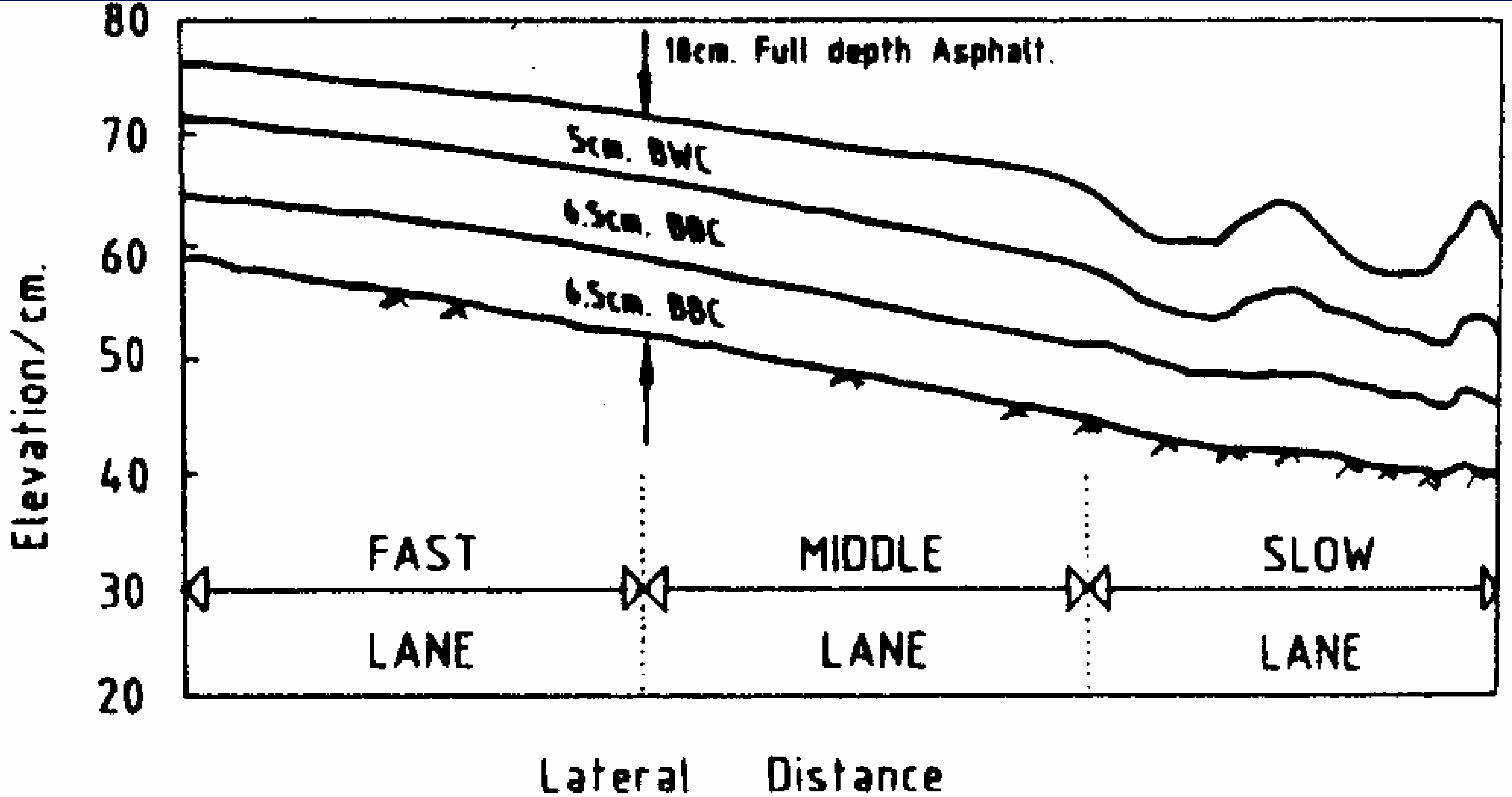
$$M_R = \frac{P}{Ht}(0.27 + \mu)$$

where,

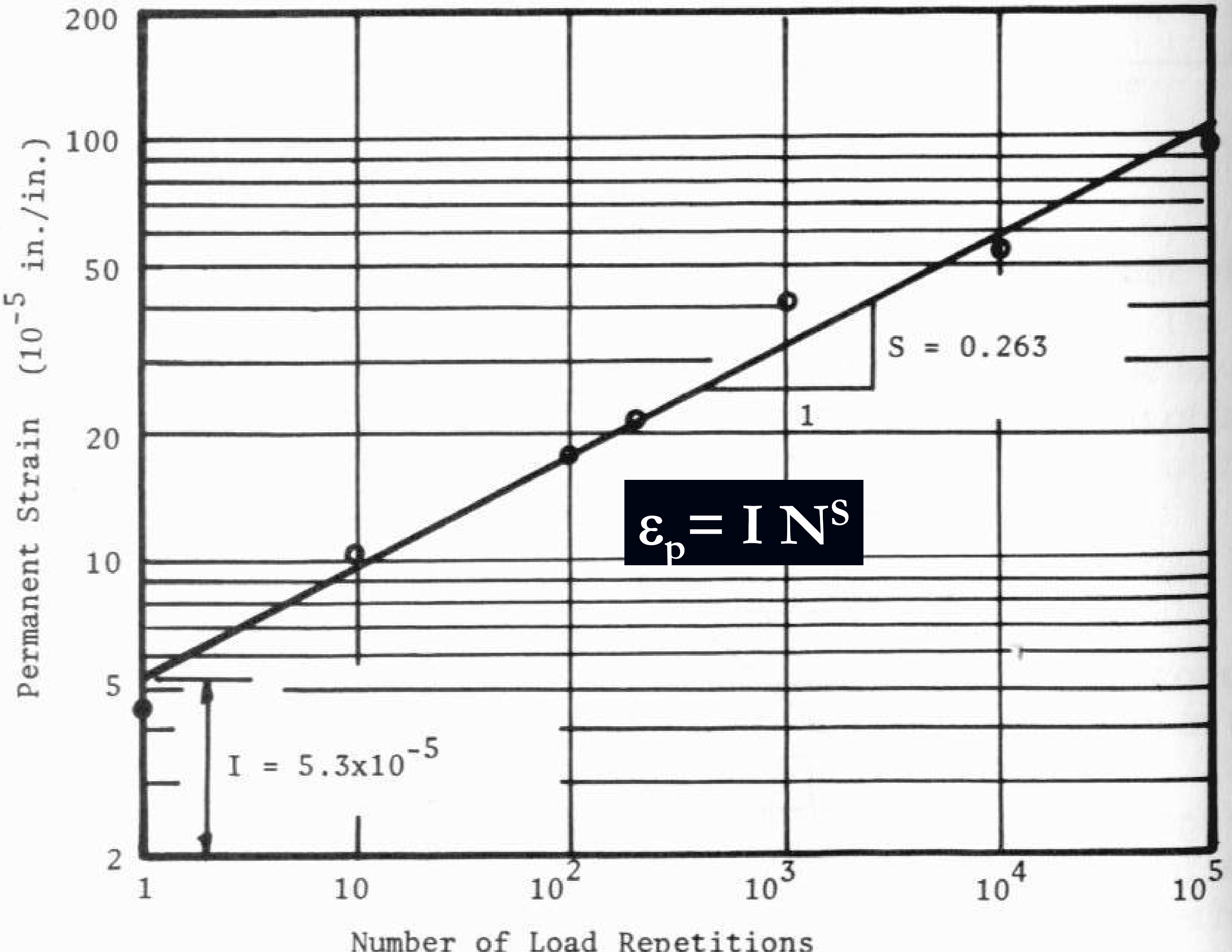
M_R = resilient modulus, psi;
P = applied load, pounds;
H = horizontal deformation, inches;
t = sample thickness, inches; and
μ = Poisson's ratio.



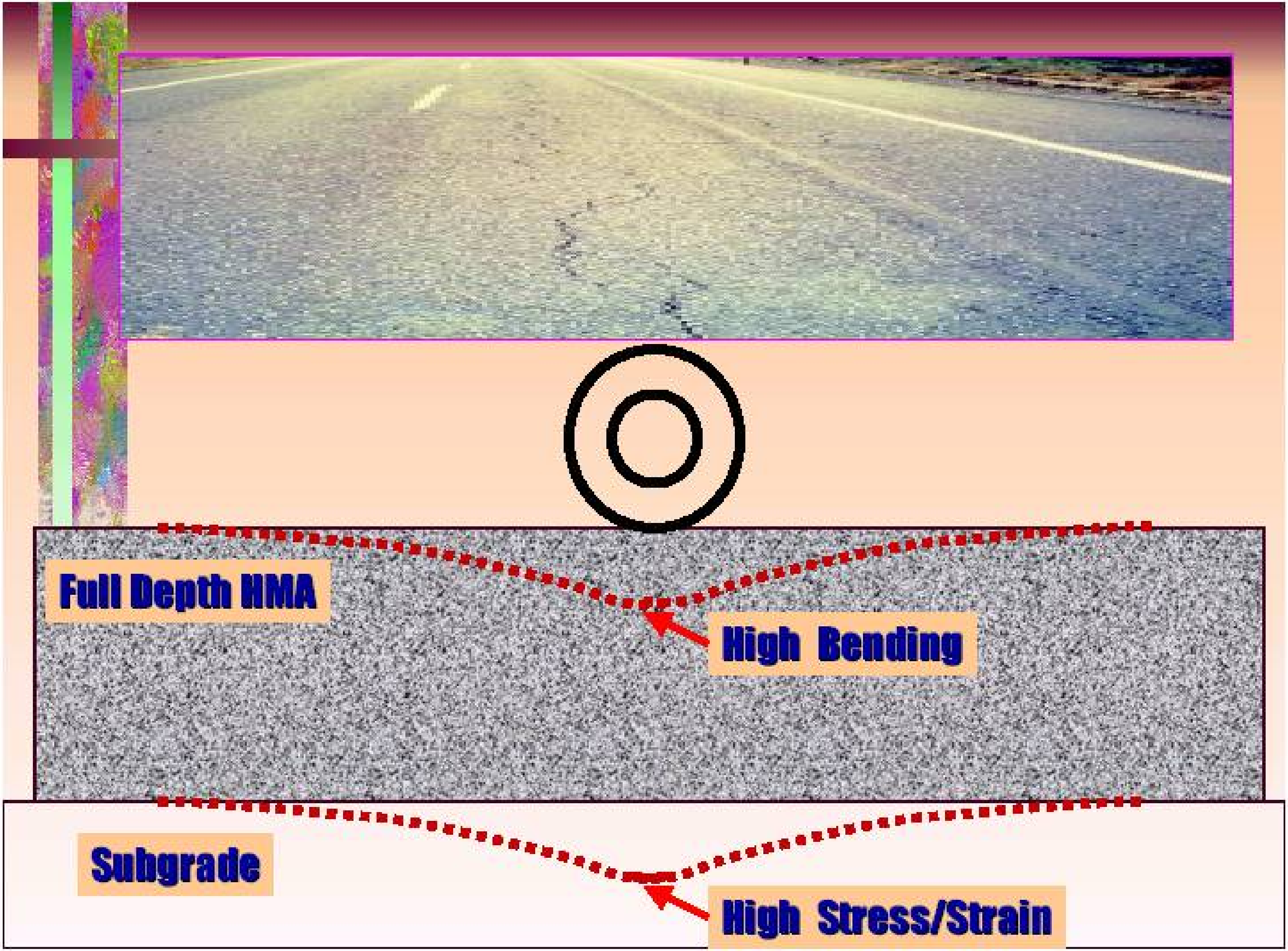

8
18
8 7 '96

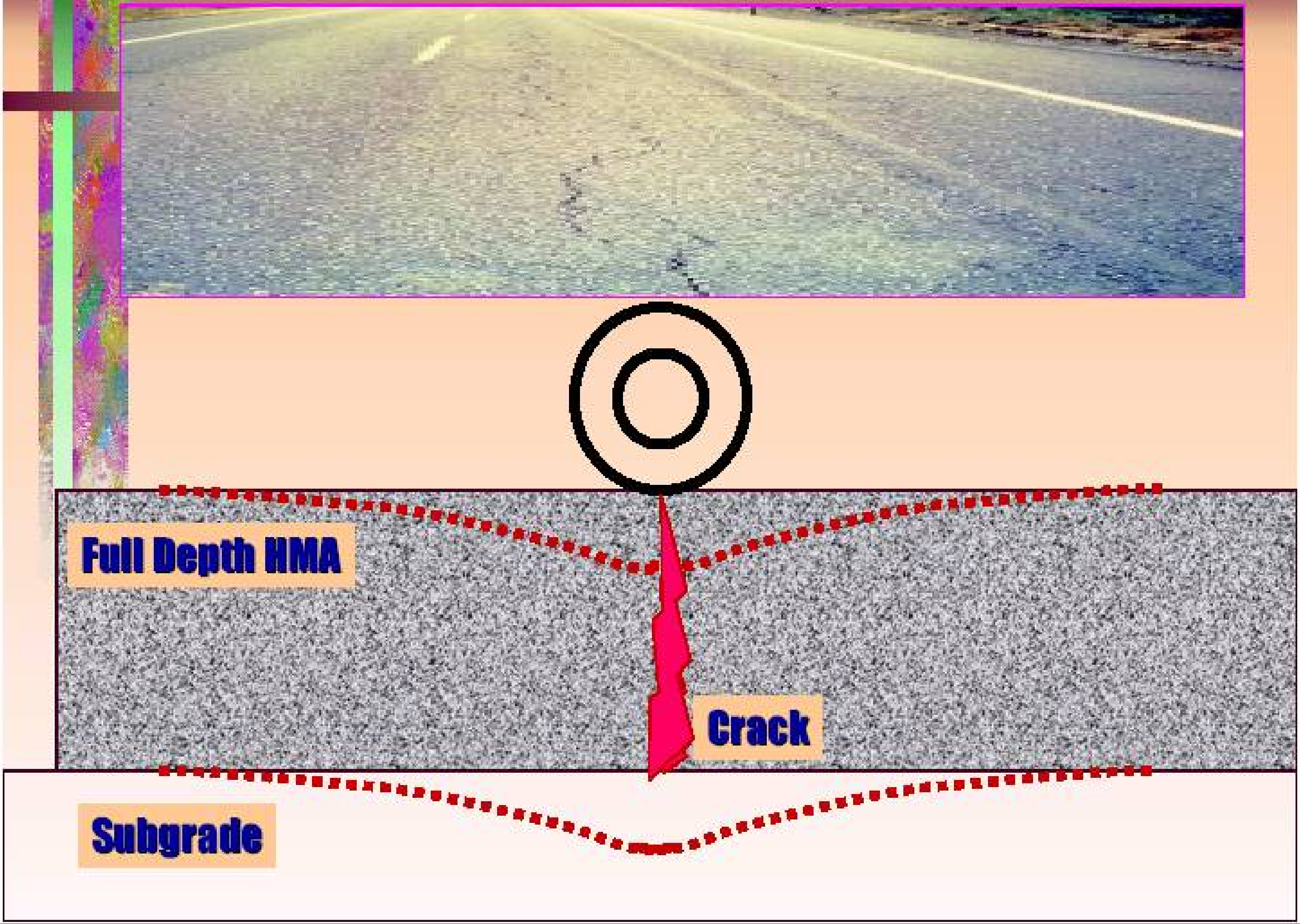


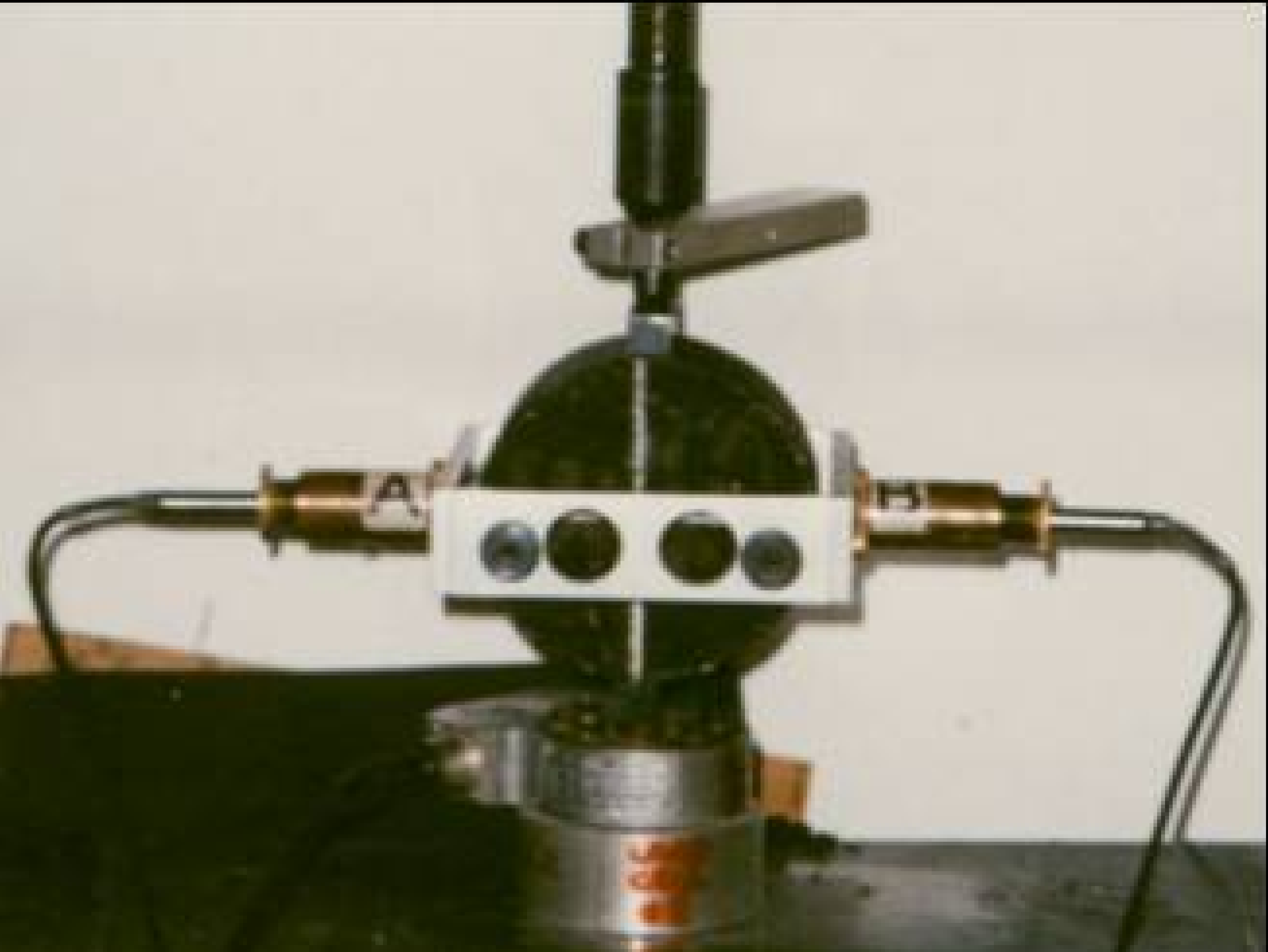
10cm. Full depth Asphalt.
5cm. BWC
6.5cm. BBC
6.5cm. BBC
FAST
LANE
MIDDLE
LANE
SLOW
LANE
Elevation/cm.
80
70
60
50
40
30
20
Lateral Distance

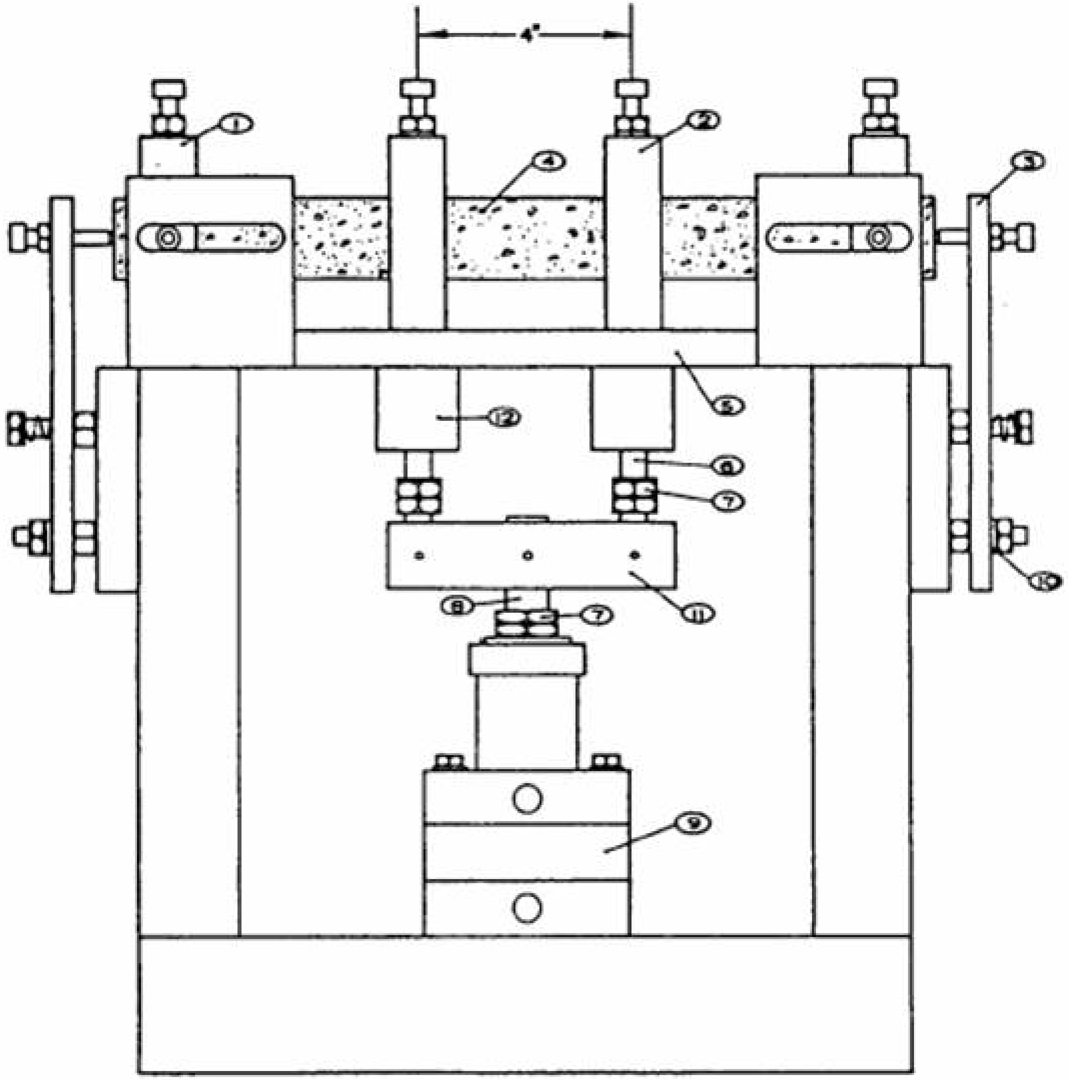

200
100
50
20
10
5
2
Permanent Strain (10^-5 in./in.)
S = 0.263
1
$\varepsilon_p = I\,N^S$
I = 5.3x10^-5
1
10
10^2
10^3
10^4
10^5
Number of Load Repetitions

HMA PAVEMENT FATIGUE


Full Depth HMA
High Bending
Subgrade
High Stress/Strain

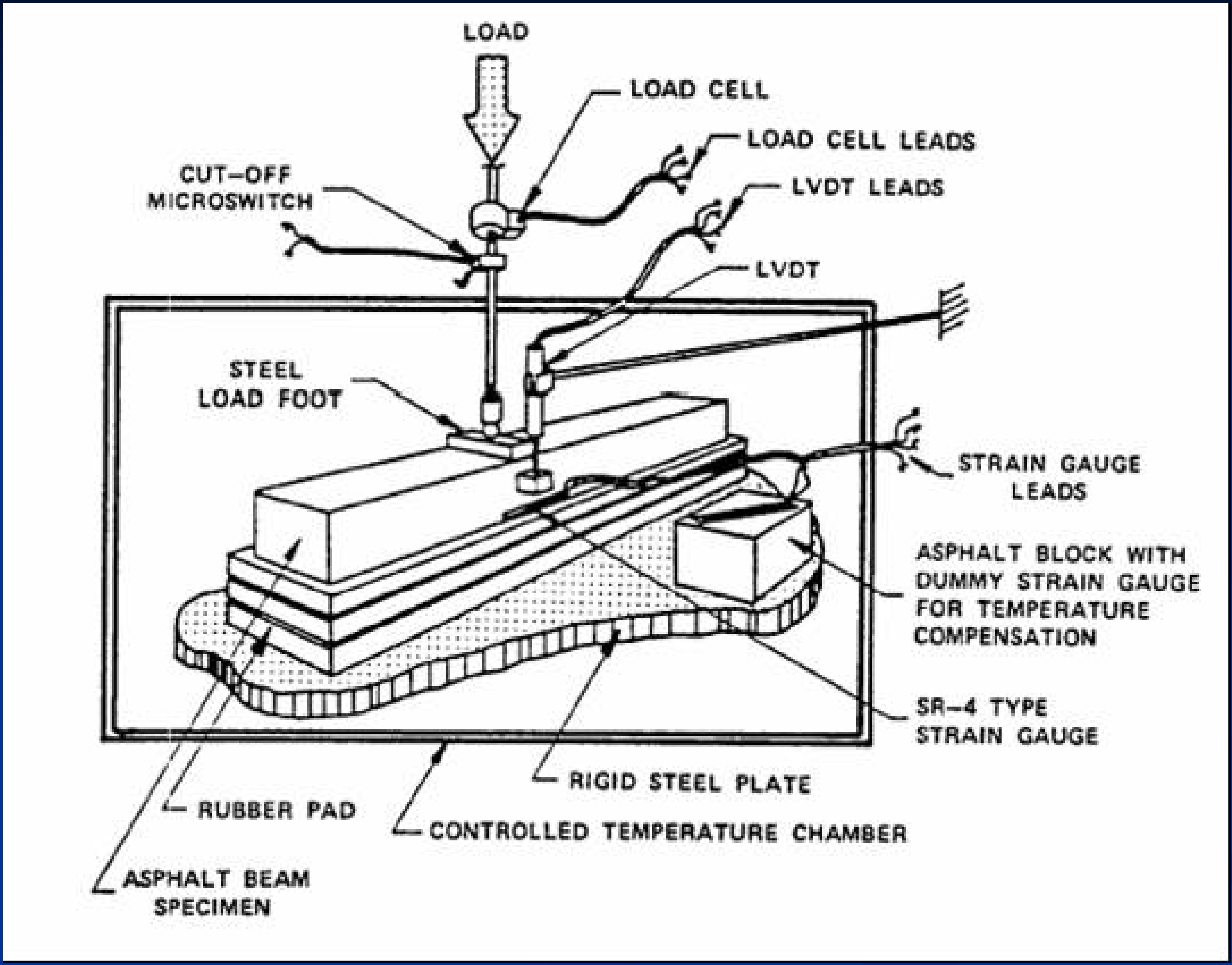

Full Depth HMA
Crack
Subgrade


A
H

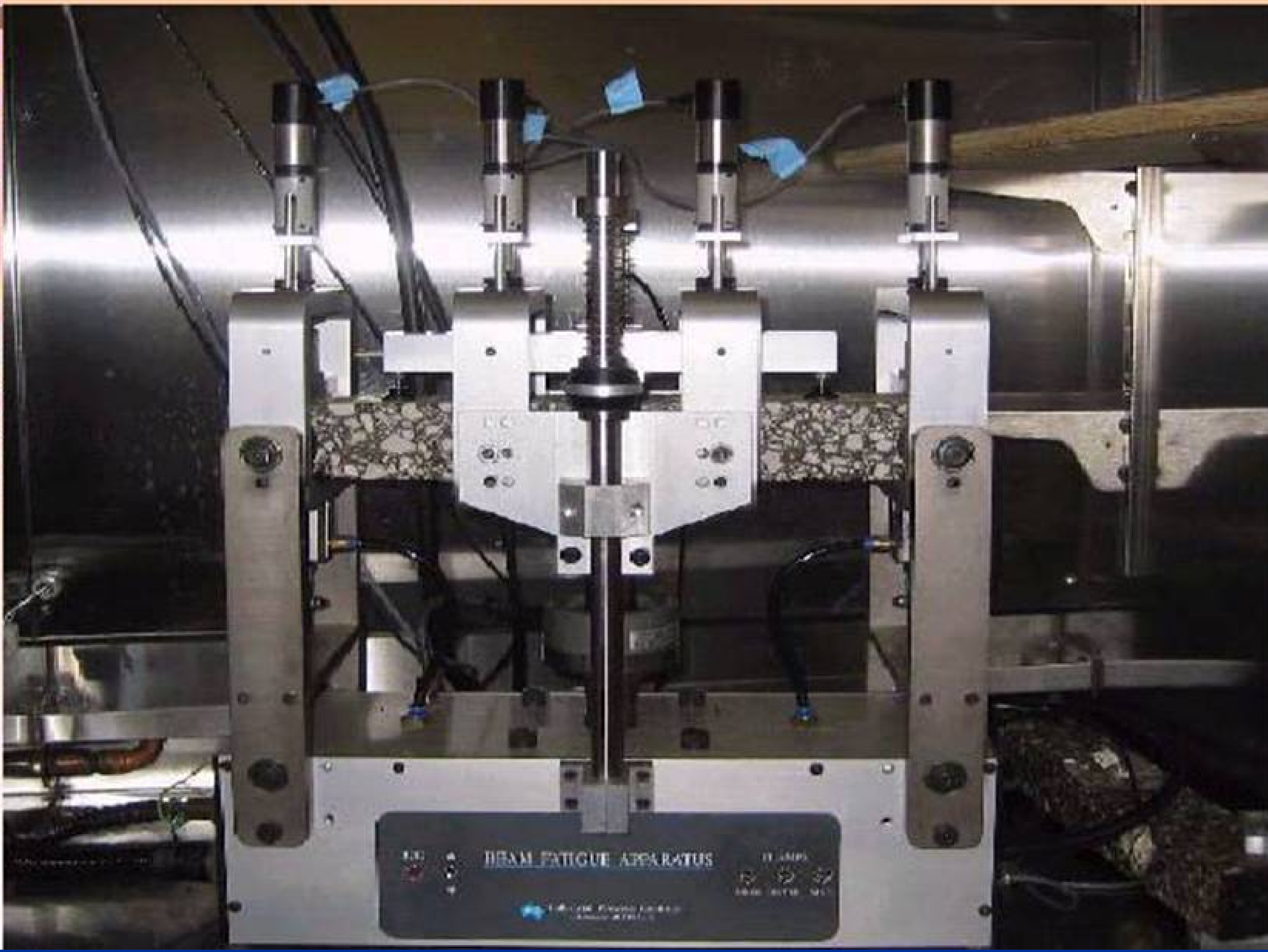


Key:

1. Reaction clamp	5. Base plate	9. Double-acting, Bellofram cylinder
2. Load clamp	6. Loading rod	10. Rubber washer
3. Restrainer	7. Stop nut	11. Load bar
4. Specimen	8. Piston rod	12. Thomson ball bushing


LOAD
LOAD CELL
LOAD CELL LEADS
LVDT LEADS
CUT-OFF
MICROSWITCH
LVDT
STEEL
LOAD FOOT
STRAIN GAUGE
LEADS
ASPHALT BLOCK WITH
DUMMY STRAIN GAUGE
FOR TEMPERATURE
COMPENSATION
SR-4 TYPE
STRAIN GAUGE
RIGID STEEL PLATE
RUBBER PAD
CONTROLLED TEMPERATURE CHAMBER
ASPHALT BEAM
SPECIMEN

FATIGUE EQUIPMENT



RBB - POLYMER MODIFIED