Soils

Pavement Design Factors

Wheel Loads Applied to Pavement

Magnitude of Wheel Loads

Type of Wheel Loads (Single or Tandem Axles)

Number of Wheel Load Applications

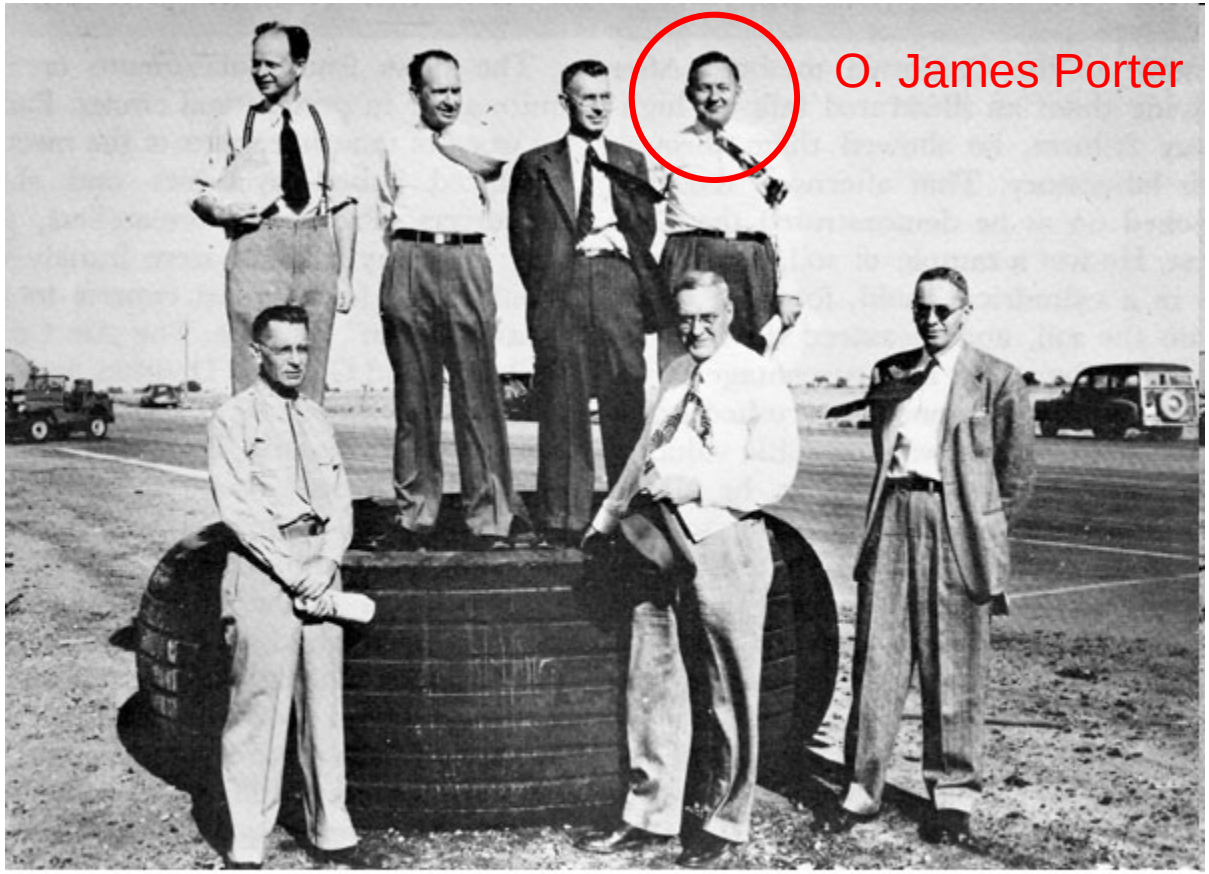
Changes over Time

Subgrade Support Provided

Seasonal Changes in Subgrade Support

California Bearing Ratio (CBR)

CBR Inventor

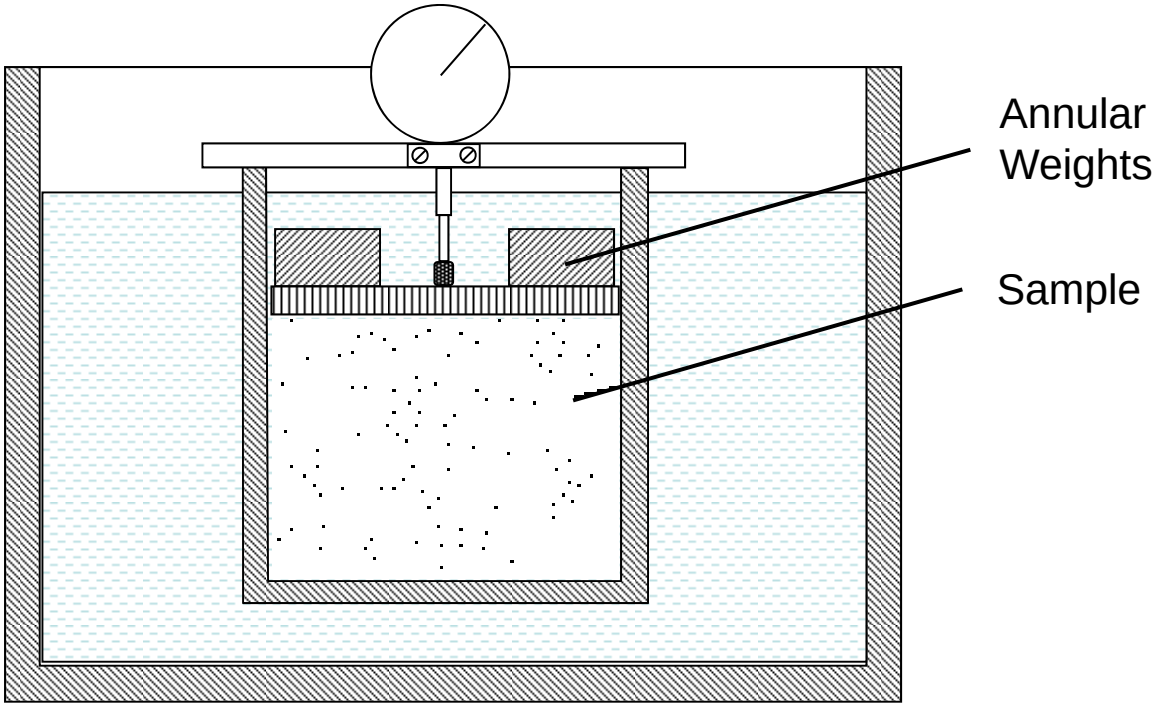


CBR Conference at Stockton Test Track, California. Front row (left to right): Colonel Henry C. Wolfe, Harald M. Westergaard, Philip C. Rutledge. Back row (left to right): Arthur Casagrande, Thomas A. Middlebrooks, James L. Land, O. James Porter

Source: http://gsl.erdc.usace.army.mil/gl-history/images/gl_img_25r.jpg

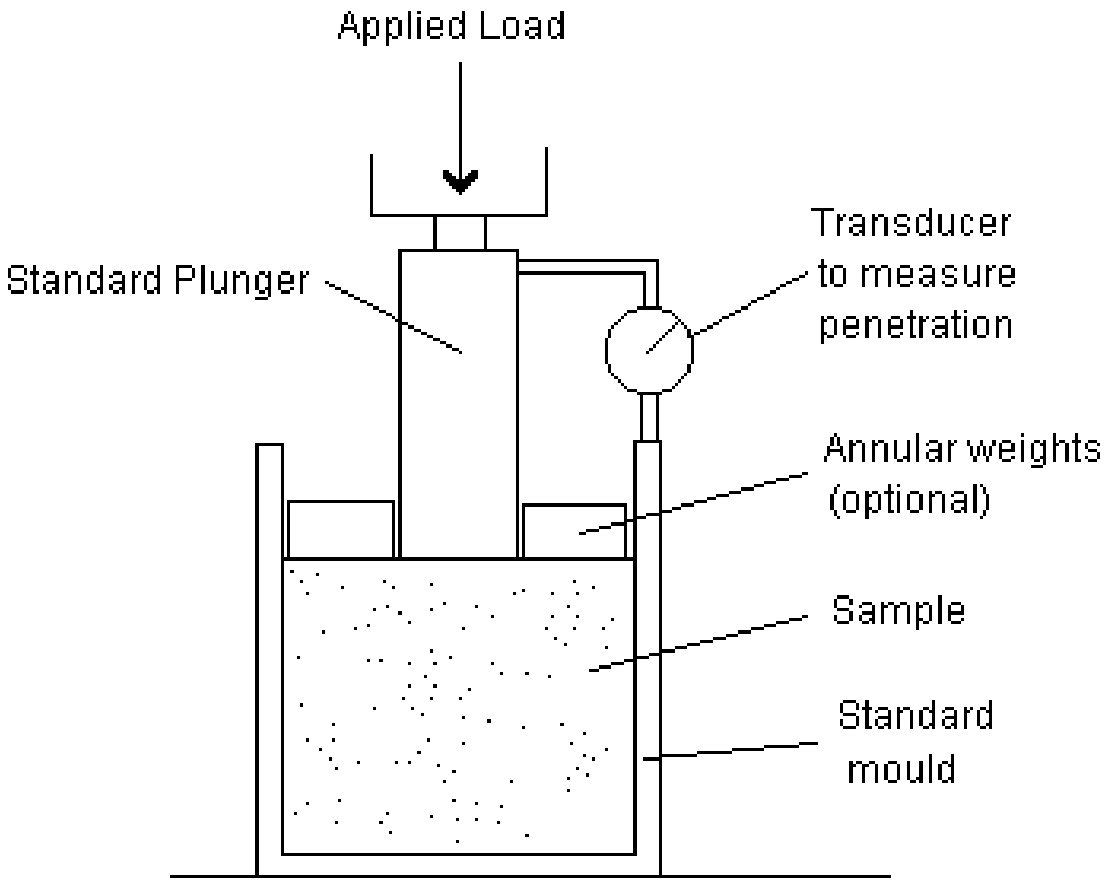
Soaking CBR Sample

4 days



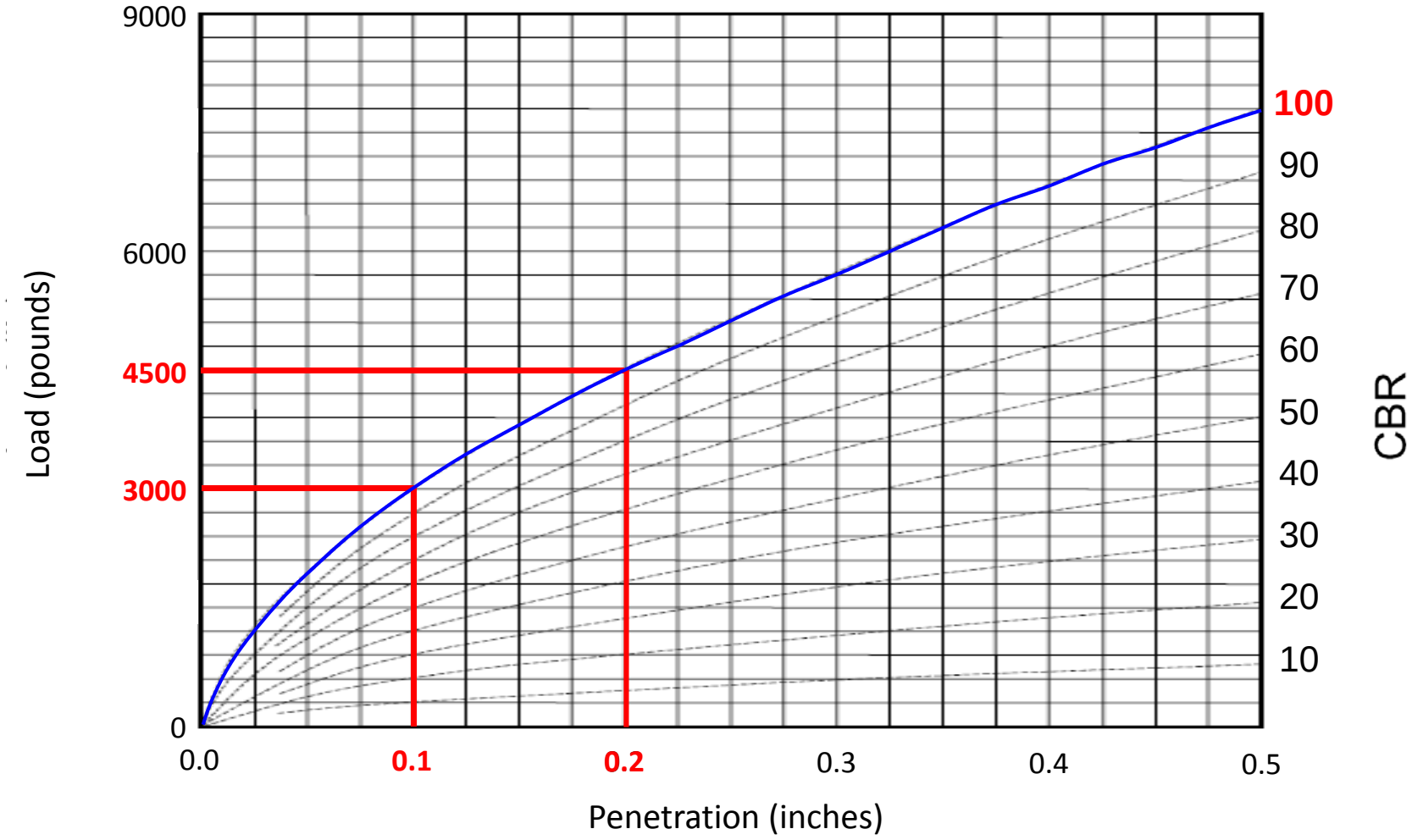
Source: http://www.archive.official-documents.co.uk/document/ha/dmrb/index.htm

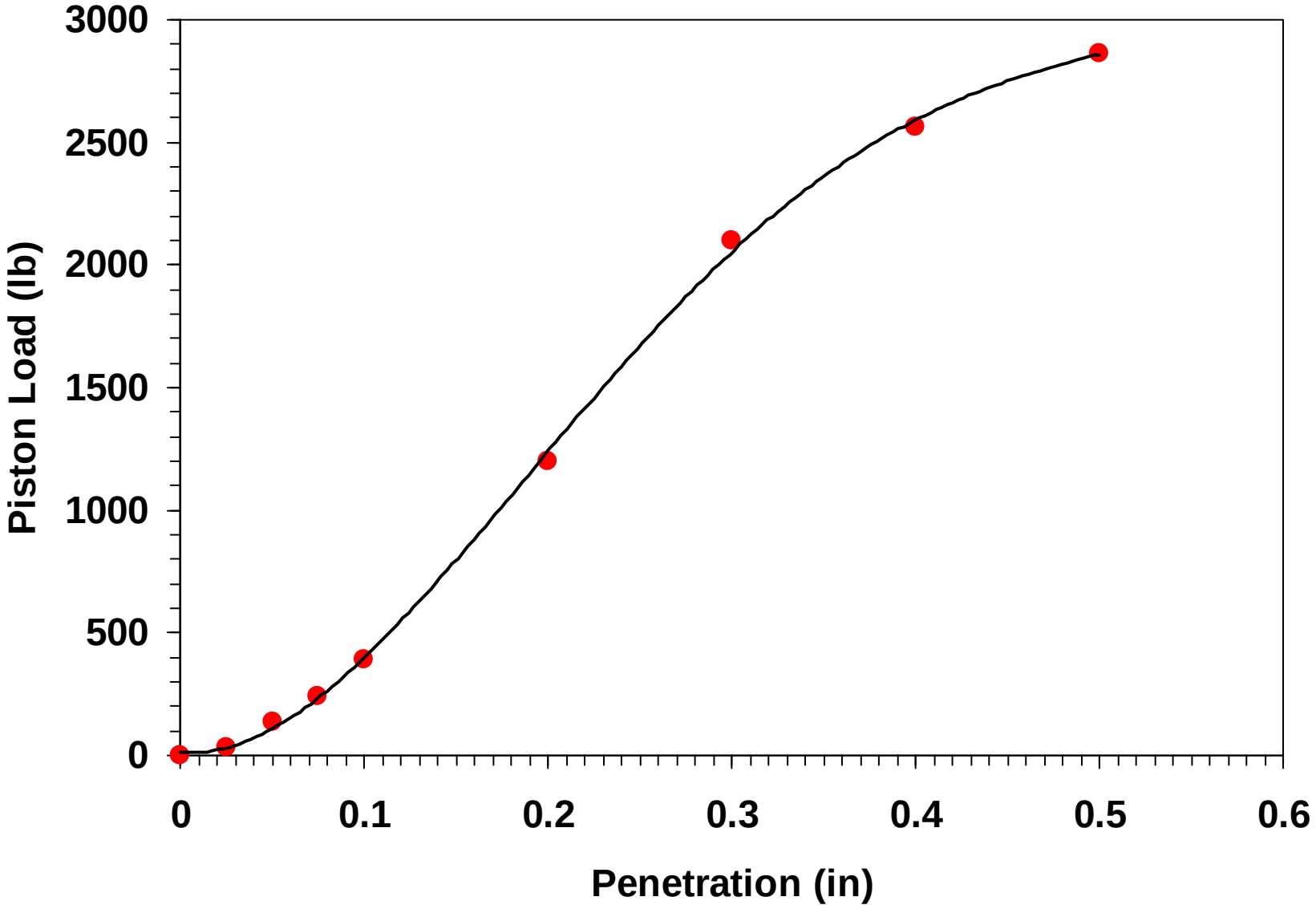
CBR Test Setup

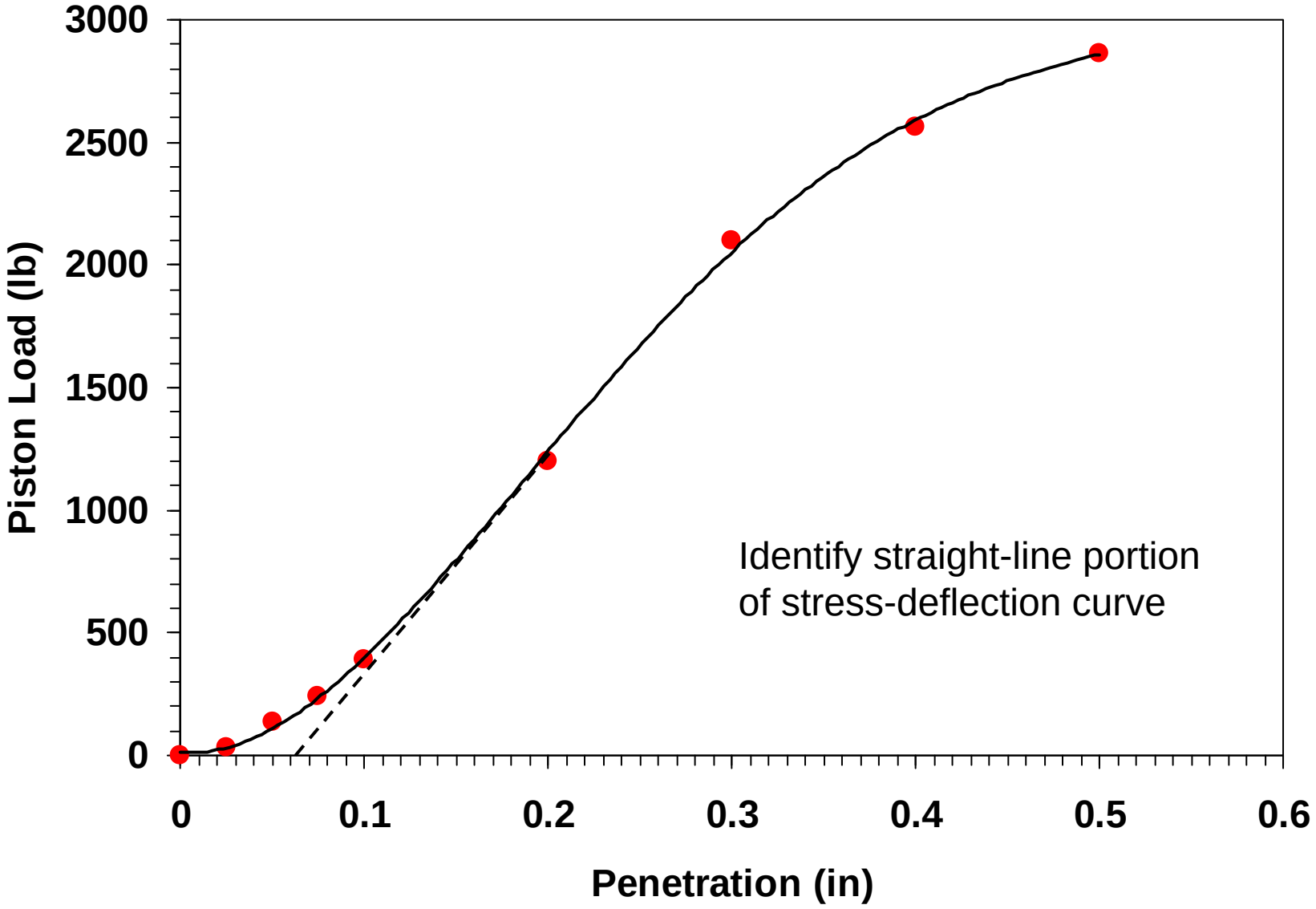


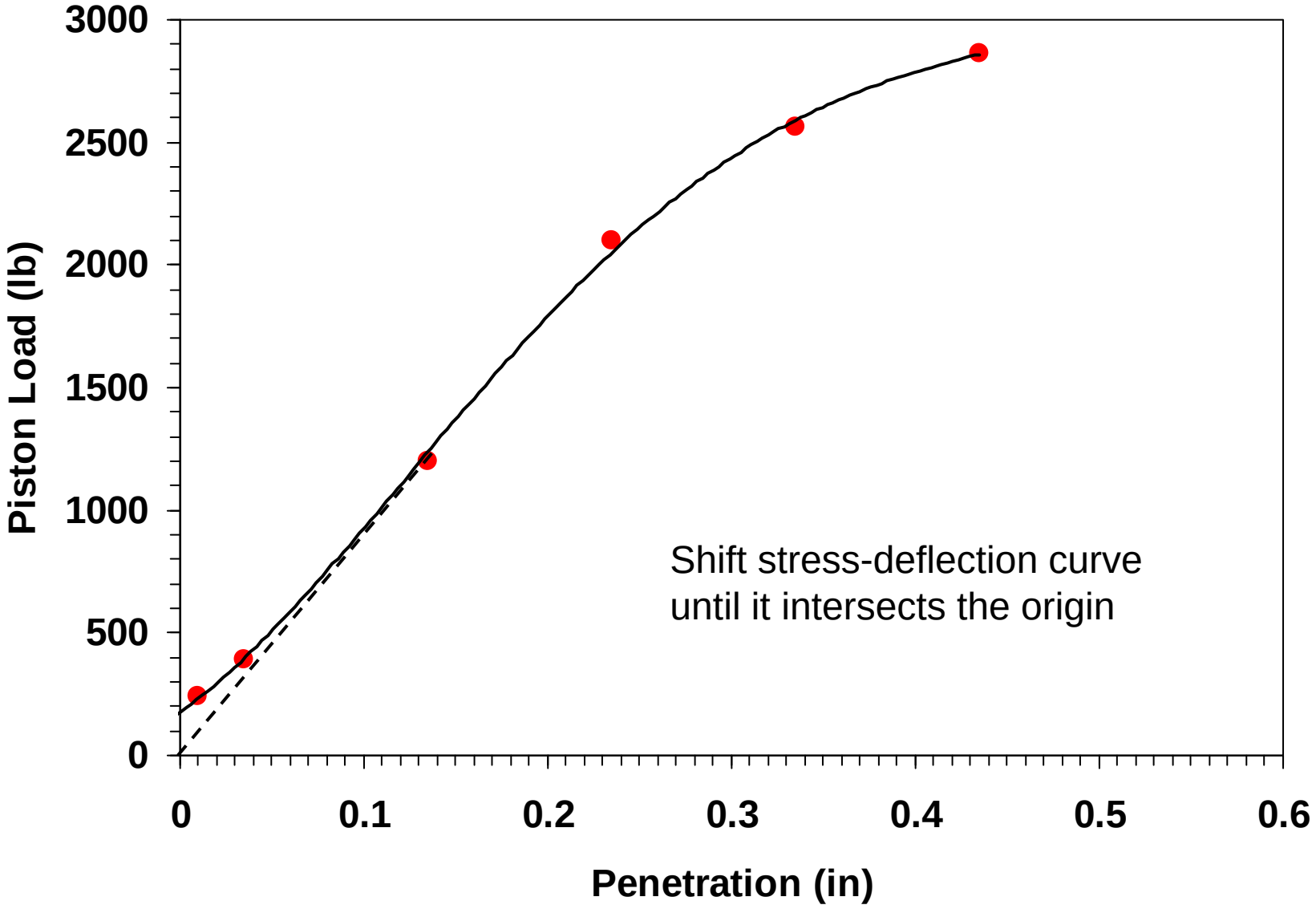
Source: http://www.archive.official-documents.co.uk/document/ha/dmrb/index.htm

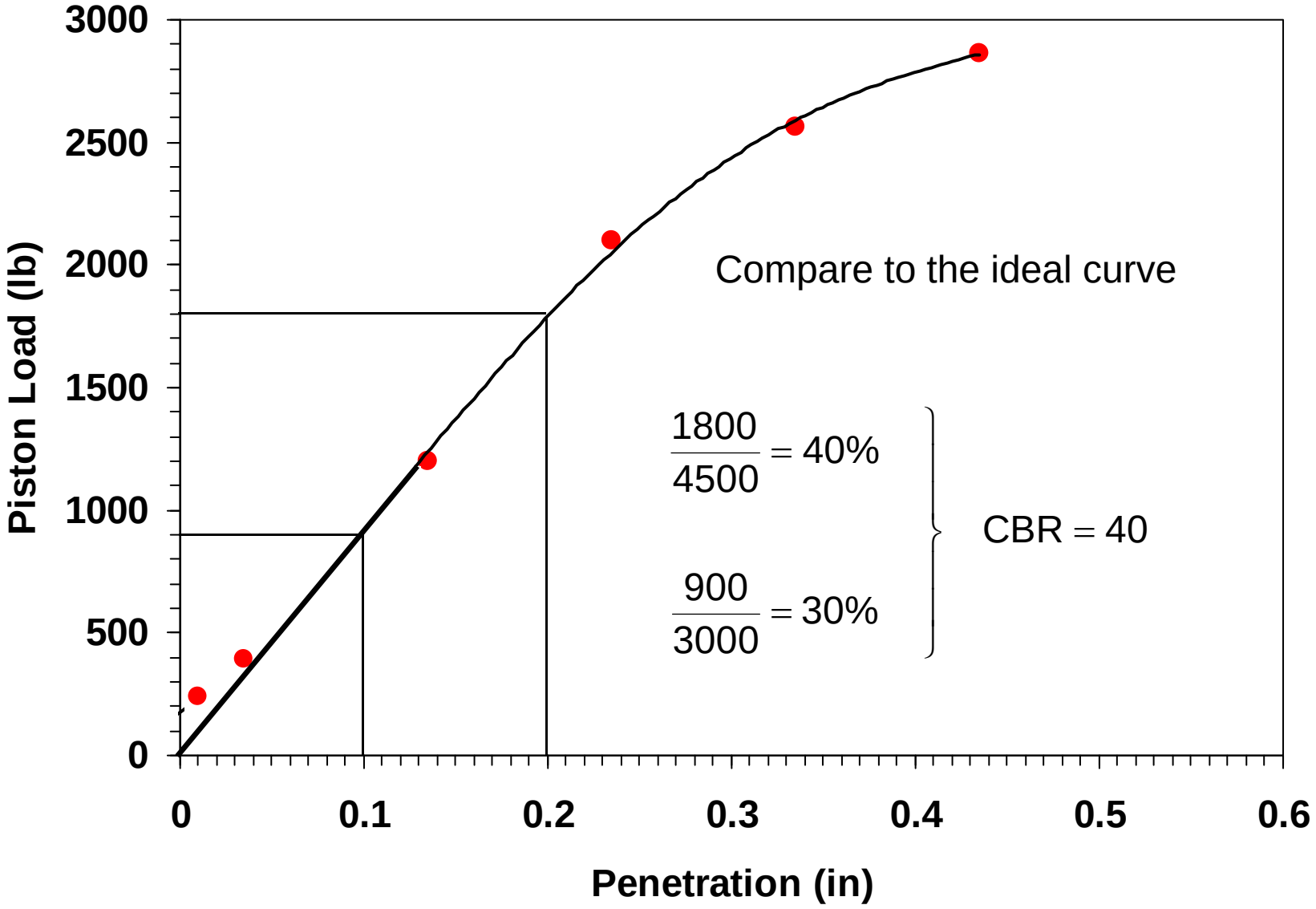
California Bearing Ratio




Piston Load (lb)
3000
2500
2000
1500
1000
500
0
0
0.1
0.2
0.3
0.4
0.5
0.6
Penetration (in)


3000
2500
2000
1500
1000
500
0
Piston Load (lb)
0
0.1
0.2
0.3
0.4
0.5
0.6
Penetration (in)
Identify straight-line portion
of stress-deflection curve


3000
2500
2000
1500
1000
500
0
Piston Load (lb)
0
0.1
0.2
0.3
0.4
0.5
0.6
Penetration (in)
Shift stress-deflection curve
until it intersects the origin


3000
2500
2000
1500
1000
500
0
Piston Load (lb)
0
0.1
0.2
0.3
0.4
0.5
0.6
Penetration (in)
Compare to the ideal curve
1800/4500 = 40%
900/3000 = 30%
CBR = 40

Typical Values of CBR

Material	CBR	Elastic Modulus (psi)
Crushed Stone (GW, GP, GM)	20 - 100	20,000 - 40,000
Sandy Soils (SW, SP, SM, SC)	5 - 40	7,000 - 30,000
Silty Soils (ML, MH)	3 - 15	5,000 - 20,000
Clayey Soils (CL, CH)	3 - 10	5,000 - 15,000
Organic Soils (OH, OL, PT)	1 - 5	< 5,000

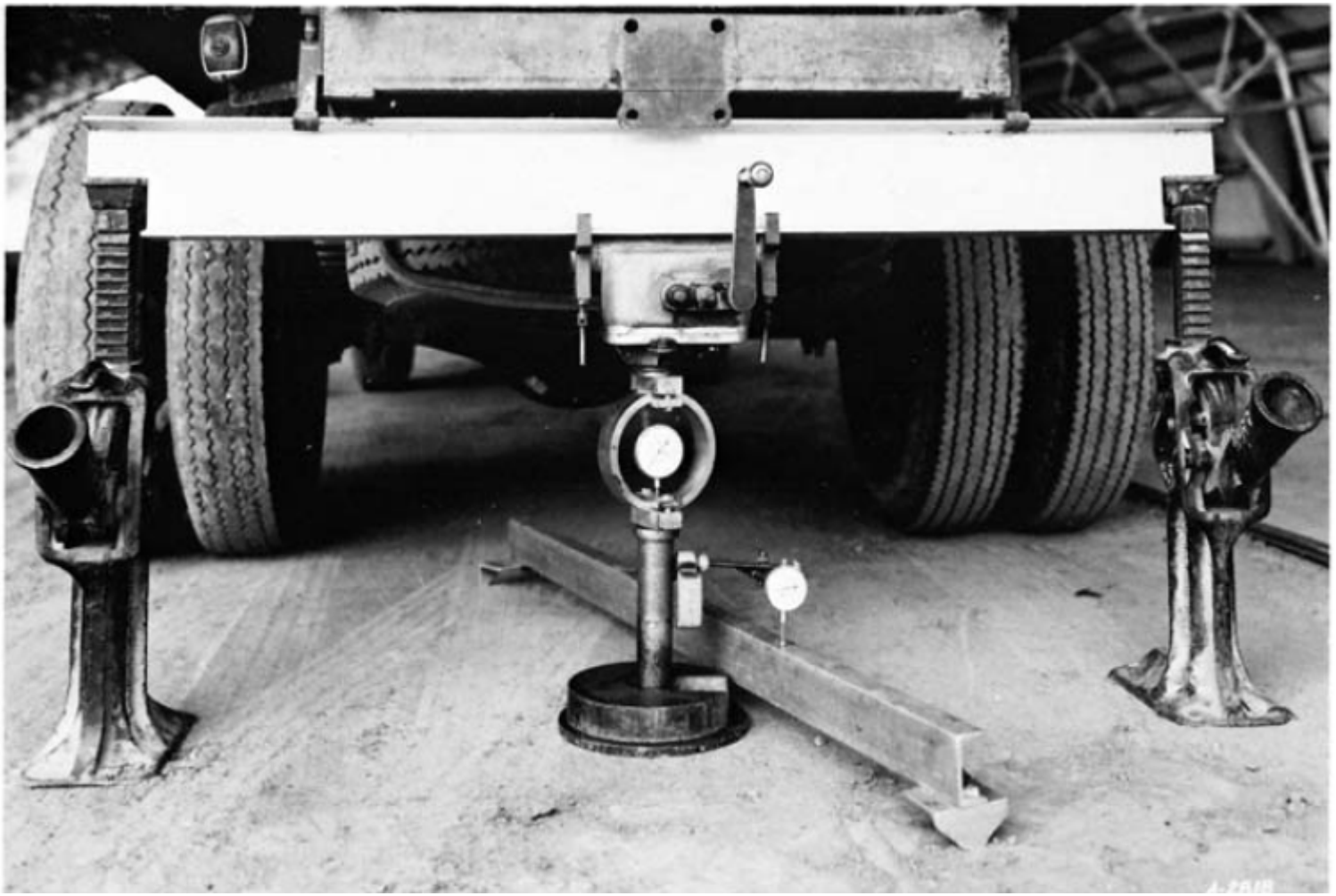
Source: WSDOT Pavement Guide Interactive CD-ROM

Typical Values of CBR

General Soil Type	USC Soil Type	CBR Range
Coarse-grained soils	GW	40 - 80
	GP	30 - 60
	GM	20 - 60
	GC	20 - 40
	SW	20 - 40
	SP	10 - 40
	SM	10 - 40
	SC	5 - 20
Fine-grained soils	ML	≤ 15
	CL	≤ 15
	OL	≤ 5
	MH	≤ 10
	CH	≤ 15
	OH	≤ 5

Source: WSDOT Pavement Guide Interactive CD-ROM

Field CBR Test



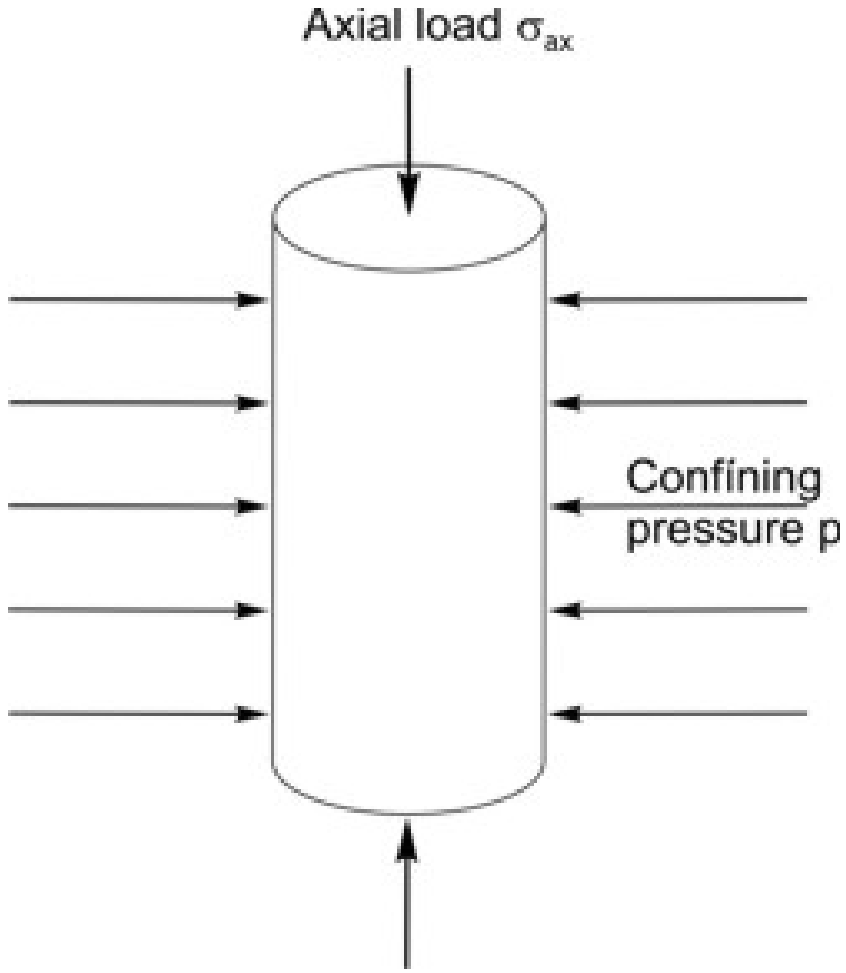
Source: *ASTM Standards on Disc*, Vol. 04.03, Designation D 4429 - 04, June 2007

Field CBR

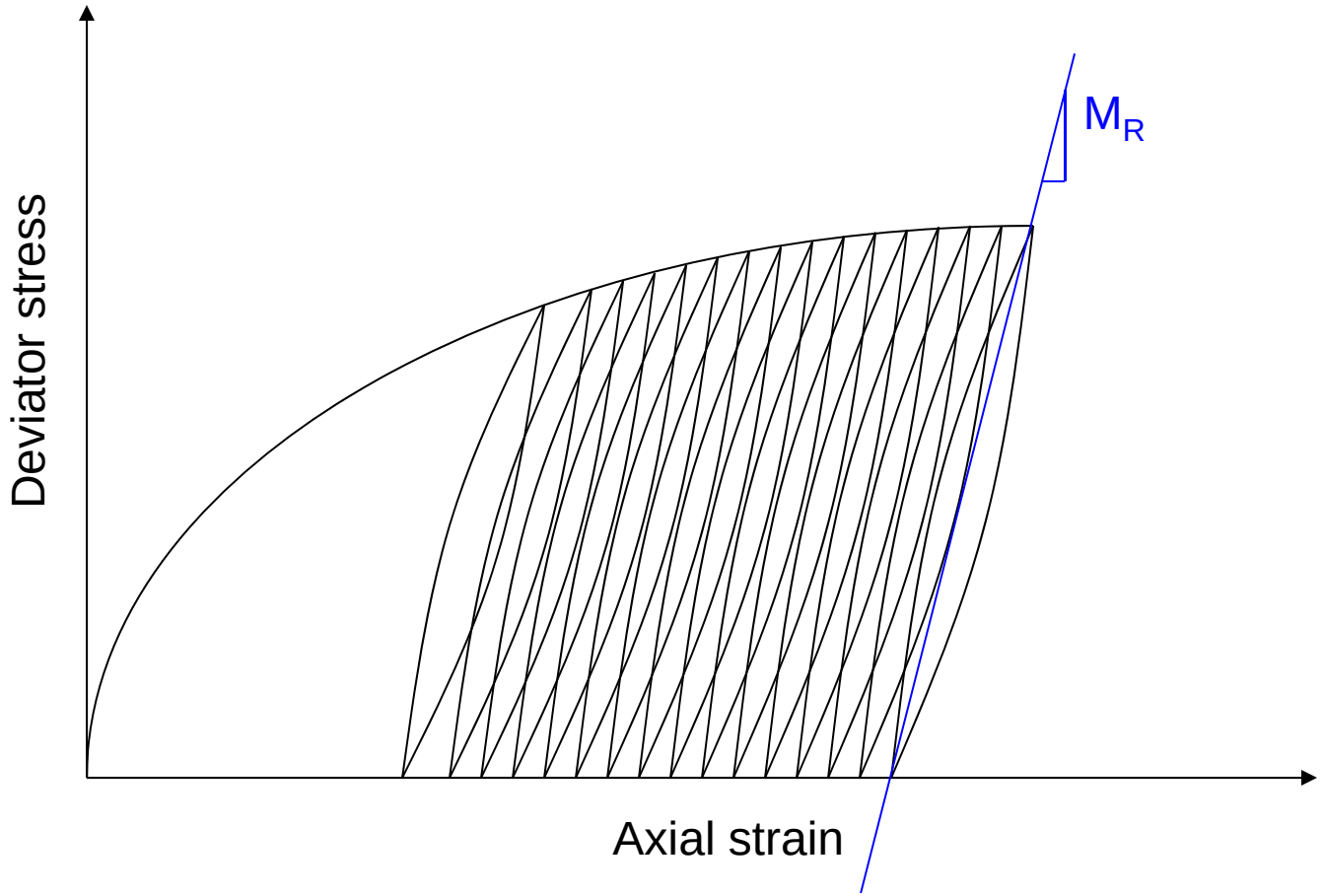
Source: http://www.ele.com/geot/cali.htm

Resilient Modulus (M_R)

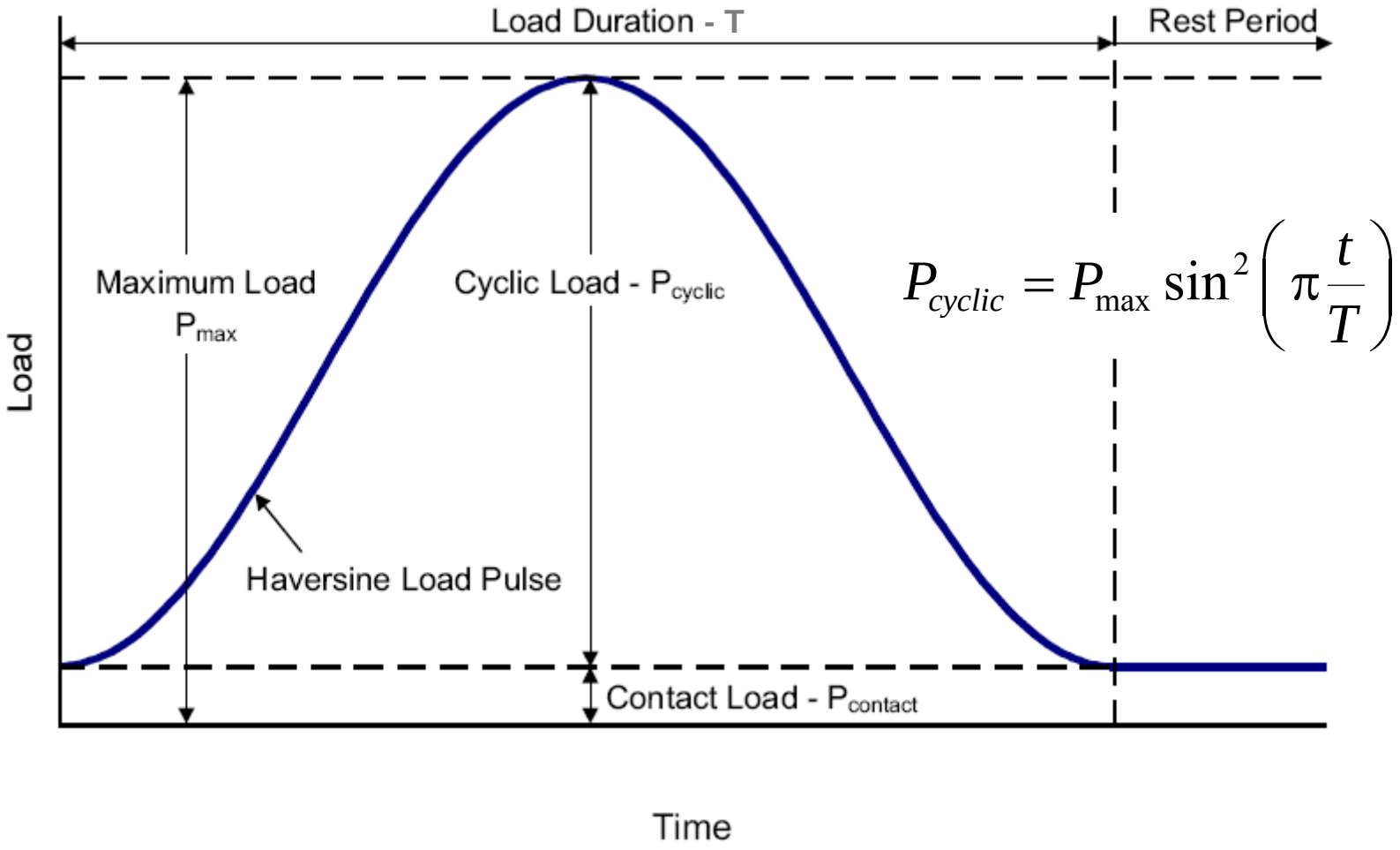
Resilient Modulus



Resilient Modulus

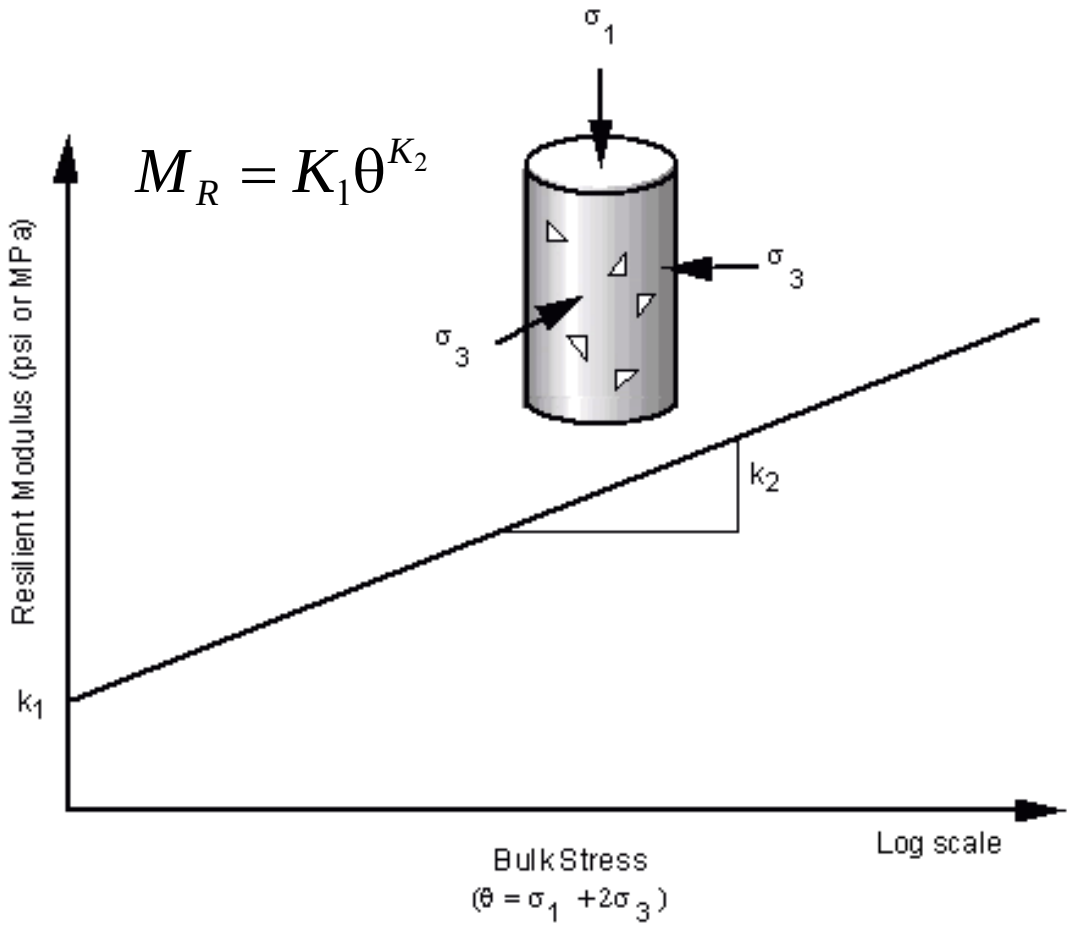


Haversine Load Pulse



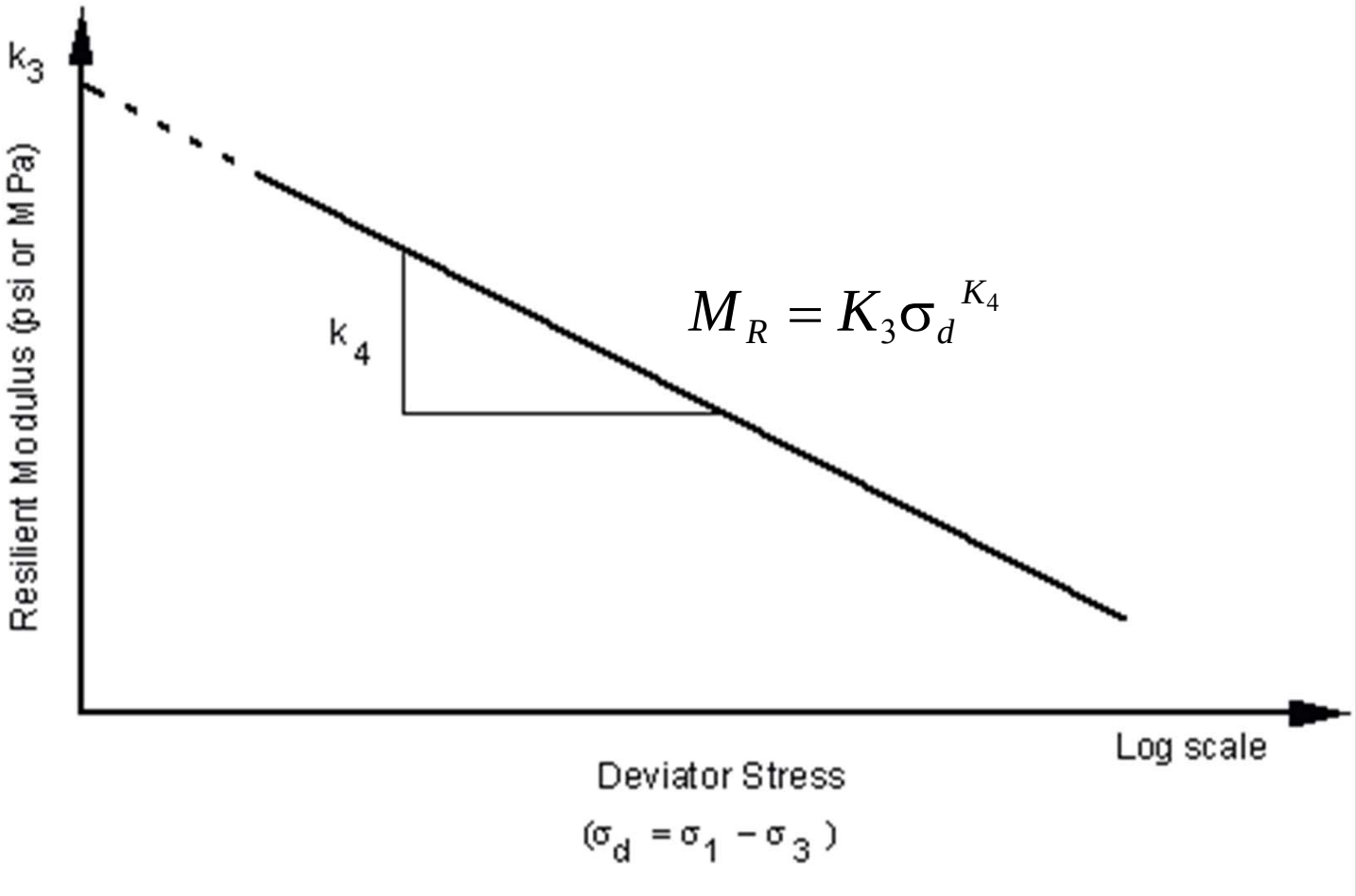
Granular Soils

$$M_R = K_1 \theta^{K_2}$$



Source: WSDOT Pavement Guide Interactive CD-ROM

Cohesive Soils



Estimating Subgrade M_R

1993 AASHTO Guide

$$M_R = 1500 \times CBR$$

WARNING: Only for fine-grained soils with soaked CBR < 10.

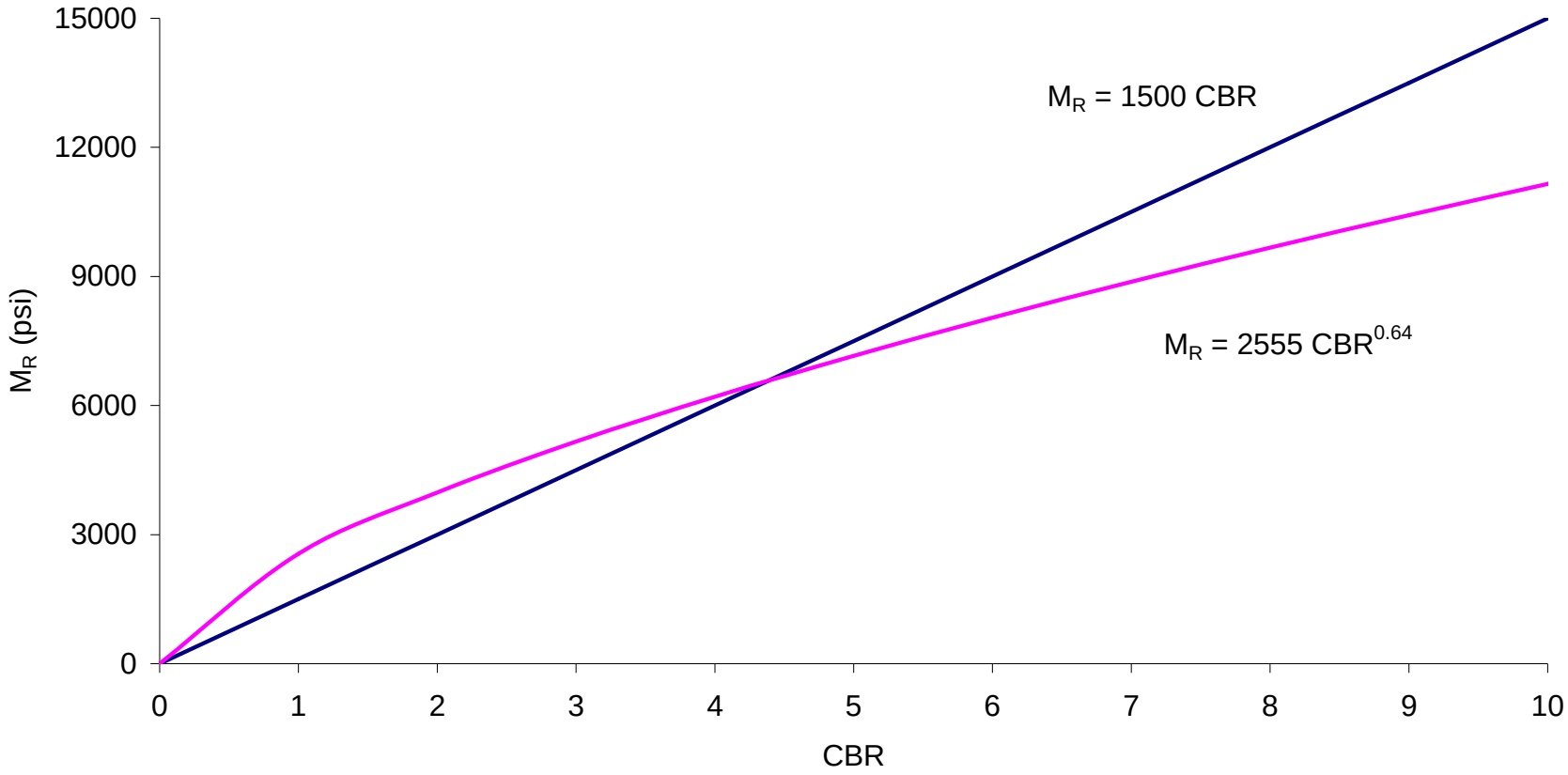
Estimating Subgrade M_R

AASHTO MEPDG

$$M_R = 2555 \times CBR^{0.64}$$

Good for a wide range of soil types

M_R vs. CBR


15000
12000
9000
6000
3000
0
M_R (psi)
0
1
2
3
4
5
6
7
8
9
10
CBR
M_R = 1500 CBR
M_R = 2555 CBR$^{0.64}$

M_R vs. CBR

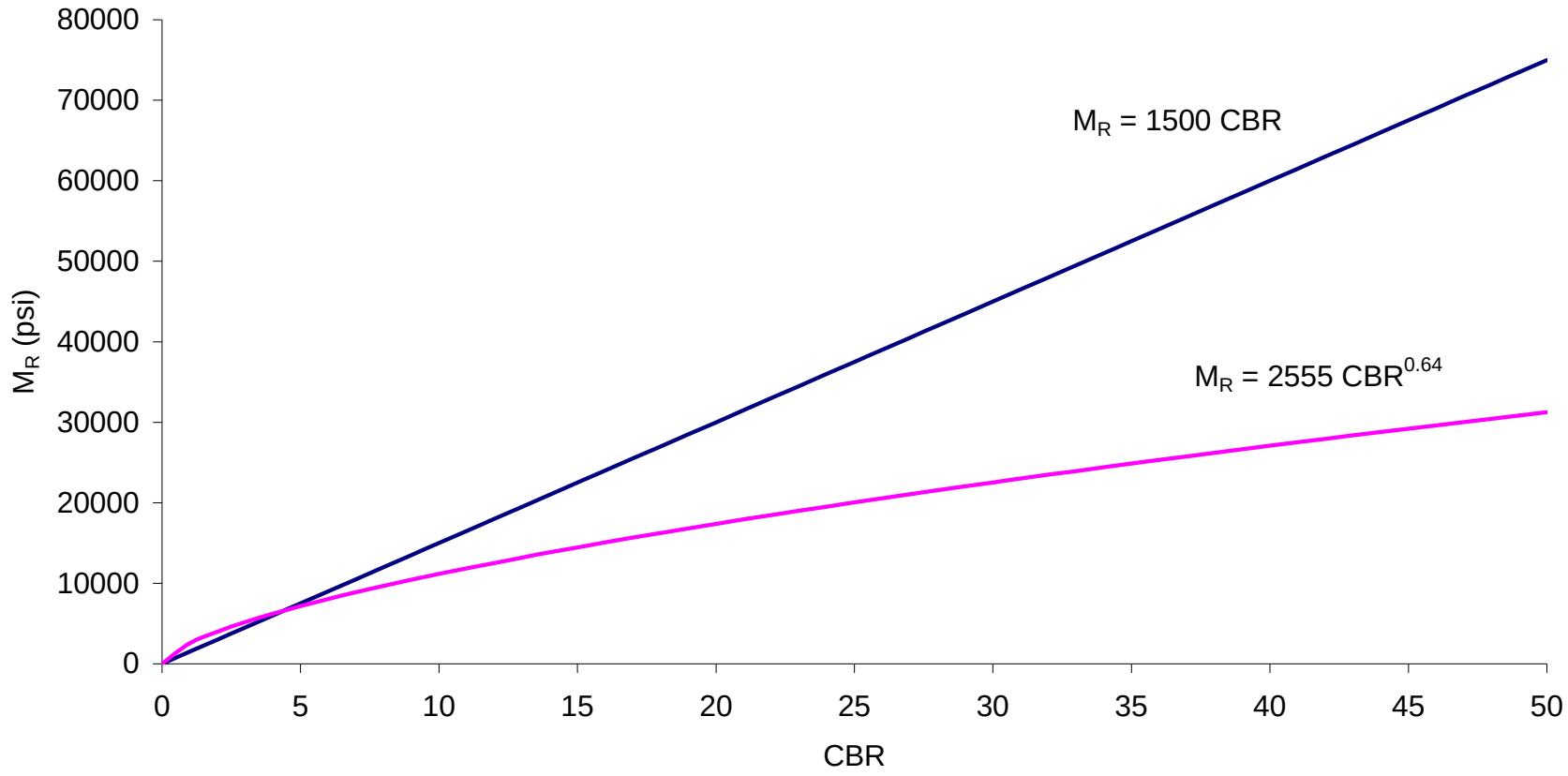

80000
70000
60000
50000
40000
30000
20000
10000
0
MR (psi)
0
5
10
15
20
25
30
35
40
45
50
CBR
MR = 1500 CBR
MR = 2555 CBR0.64

Plate Load Test
(k)

Plate Load Test

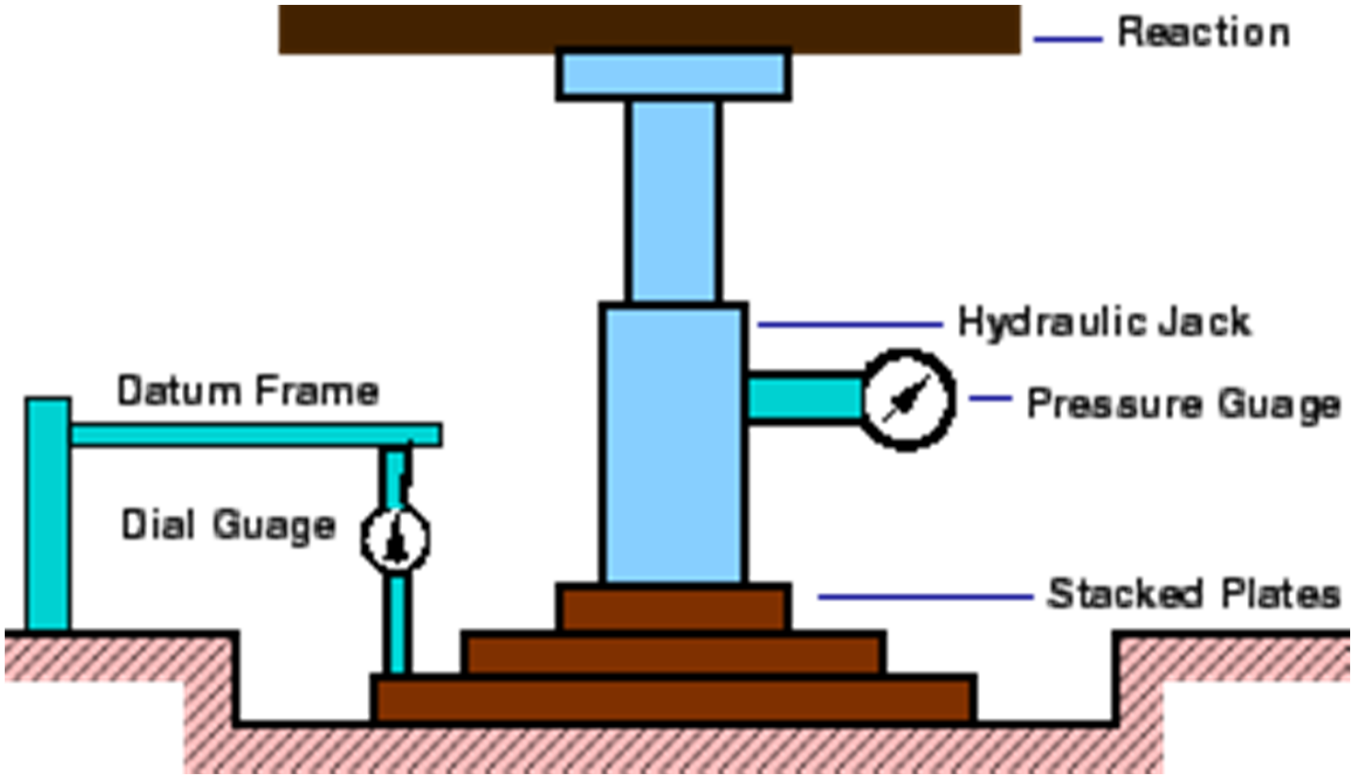


Plate Load Test

Plate Load Test

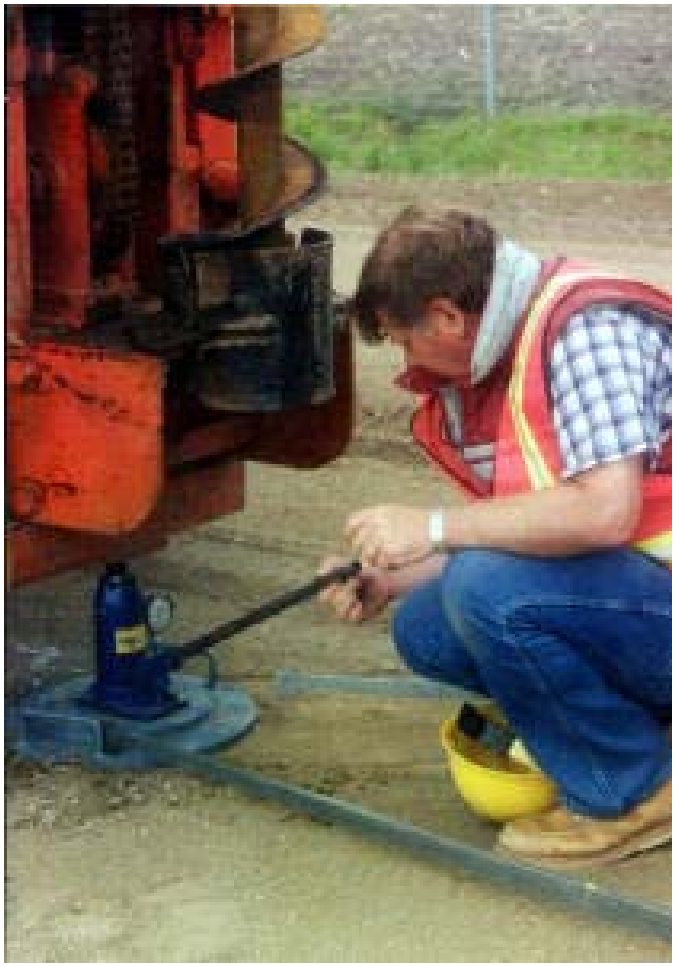


Plate Load Test

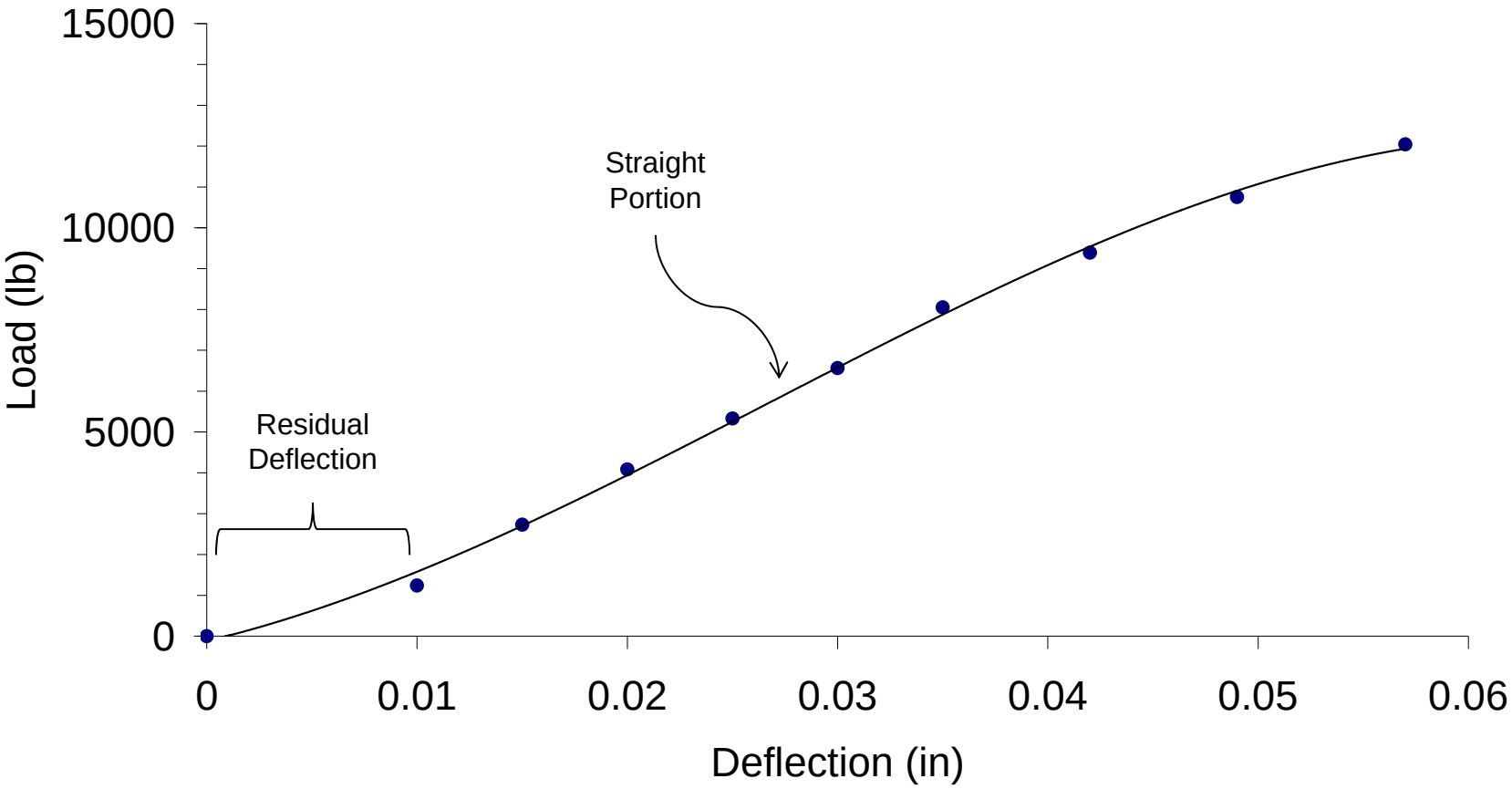
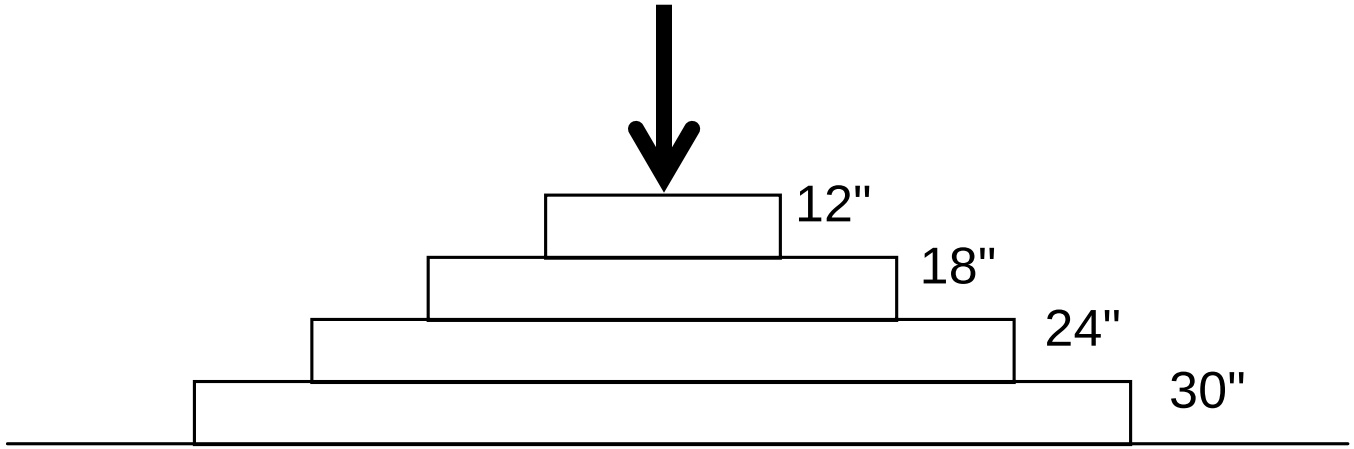


Plate Load Test



$$A = \pi r^2 = \pi(15\,\text{in})^2 = 707\,\text{in}^2$$

Plate Load Test